



George Eastman House
International Museum of Photography and Film
& Image Permanence Institute,
Rochester Institute of Technology

The History and Conservation of Glass Supported Photographs

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In Photograph Conservation

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ABSTRACT

This research project is intended to provide for students of photograph conservation the basic information on the history, manufacture, deterioration and conservation of glass supported photographs. The result is the production of a teaching text for the photograph conservation community. The research has been broken up into two parts. The first is a synopsis of glass supported photographs will be created that will include an identification tree; and the second is a discussion of the conservation issues involving glass supported photographs, illustrated with case studies. A case study of the treatment of the interpositive of Abraham Lincoln interpositive is the base upon which the rest of the case studies are based. This report is intended to aid the education of conservators, raise interest in research in the area, and promote preservation.

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INTRODUCTION

Glass has been an integral part of the art and science of imaging since the very dawn of photography. Joseph Nicéphore Niépce used glass in some of his early experiments such as the Physautotype in 1822, as did his nephew, Niépce de Saint-Victor, and John Frederick William Herschel. Henry Talbot experimented with albumen on glass. There are more than 20 photographic processes on glass, and when the permutations and variations of these are taken into consideration, the number increases to no fewer than 40 processes. In order to treat photographs properly, one must understand their history and production.

Many of the most historically significant photographs of the 19th and early 20th centuries were shot on glass plates. Mathew Brady's often seen, civil-war-era photographs, Timothy O'Sullivan's pioneering images of the American West, Alexander Hesler's portrait work, and countless other iconic images were all taken with glass plates. These early pioneers saw the advantages of glass as a support structure – it is clear, dimensionally stable, easy to clean, and reusable. However with these advantages also come certain drawbacks – most notably that glass is easily broken and succumbs to chemical deterioration.

The deterioration of glass and glass-supported photographs is not just a modern difficulty; it was recognized historically as well. The importance of high quality glass in photography was an issue revisited many times in the early years of the craft. Having observed weeping and color shifting skylights and photographs, photographers sought out the best glass for their purposes. Even with the best available glass, broken plates were inevitable. However, conservation of glass-supported photographs was infrequent. Many times copy negatives were made onto a new support and the original was discarded. An example of a historical treatment for broken glass-supported photographs was to sandwich the shards between two sheets of glass and bind the three layers together with tape around the perimeter. Modern conservation of glass supported photographs has not progressed much further. This three-layer treatment is still common practice today.

Given the fact that there are so many historically significant images on glass, and that glass has been omnipresent until as recent as 2001 when Kodak ceased production of T-Max plates, it is surprising that there has been so little research into the conservation of glass-supported photographs. The few studies that have been made are dated, inaccessible, too narrowly focused, or too broadly conceived to be of much use to the photograph conservator. The current philosophies and methods of glass repair need to be questioned and reevaluated, and innovative treatment solutions need to be determined. The current research is an initiative to conserve glass supported photographs. Deteriorated or broken plates will not be returned to their original condition, but they can be conserved.

In August of 2005, a broken interpositive of Abraham Lincoln, made by George B. Ayres, after Alexander Hesler, came into the George Eastman House conservation lab

for treatment. This object presented the perfect opportunity to examine innovative treatment options for broken photographs on glass. As a result, many groundbreaking treatment options have been explored. While some of the procedures that were used in the final treatment of this object were already in practice, many new treatment techniques have been developed. Some other treatment options have been explored in the course of this research in the series of case studies. Though there are still many avenues to explore, there is now a better understanding of some of the dynamics of treating photographs on glass.

PART 1. HISTORY OF PHOTOGRAPHIC PROCESSES ON GLASS

Summation of the glasses used in Photography

The importance of high quality glass as a photographic support was an issue that was revisited many times in the early years of photography. Observations of weeping and color shifting skylights and deteriorated photographs lead photographers to seek out the best glass for their purposes. Patent plate glass was considered the best, as stated by a Frederick Scott Archer in 1854:

“Many pictures have been spoiled, which otherwise would have been good specimens of skill, by the want of due care and attention in the choosing and proper preparation of the glass plates...

Thin patent plate glass is the best kind at present in use, but it has one defect, its color is too green; consequently, it gives an unpleasant tone to positives, which, being looked at through the body of the glass, are affected by it. It would be a great advance if a white glass with the same polish and flatness could be procured.

The next [best] glass to patent plate is flatted crown. It is much cheaper, and very thin; one side of this kind of glass is highly polished, and well adapted for the purpose, but the other side should be avoided; it is rough and gritty to the touch, with a slight haze upon it; the difference between the two sides is easily detected; very often merely passing the finger over it will be sufficient, or examining it in a good light.

Sheet-glass is now made very clear and flat, and is often sold for flatted crown. It is more equally polished on both sides, but it is liable to be specky and rough in places, and the polish generally is more defective; this kind of glass should be avoided if possible. Specks, or scratches of any kind, are liable to produce defects in the picture; consequently, the glass should be examined, to choose the best side previous to covering it with collodion.”

In its pure form glass is a transparent, hard-wearing, essentially inert, strong but brittle, and biologically inactive material that can be formed with very smooth and impervious surfaces. These properties can be modified or changed with the addition of other compounds or heat treatment. The basic ingredients are amorphous silicon dioxide (SiO_2), soda (sodium carbonate Na_2CO_3) or potash, the equivalent potassium compound to lower the melting point, and lime (calcium oxide, CaO) to restore insolubility. The resulting glass contains about 70% silica and is called a soda-lime glass. Soda-lime glasses account for about 90% of manufactured glass.

Cylinder or broad sheet glass, and crown glass were the two processes for making glass for windows up until the 19th century and therefore, the two varieties of glass used in photography during that period.

Broad sheet glass, also known as *Cylinder glass* was made by blowing molten glass into an elongated balloon shape with a blowpipe. Then, while the glass was still hot, the

ends were cut off and the resulting cylinder was split with shears and flattened on an iron plate. The quality of this was poor, with many imperfections and limited size.

Crown glass was produced by blowing molten glass into a "crown" or hollow globe. This was then flattened by reheating and spinning out the bowl-shaped piece of glass (bullion) into a flat disk by centrifugal force, up to 5 or 6 feet in diameter. The glass was then cut to the size required. Because of the manufacturing process, the best and thinnest glass is in a band at the edge of the disk, with the glass becoming thicker and more distorted towards the centre.

Plate glass developed out of the manufacture of broad sheet glass and the need for higher quality glass. The ingredients varied with manufacturer, but they all had special care taken concerning purity. Early plate glass was made from broad sheet glass by laboriously hand grinding and polishing both surfaces. It was later developed into a process whereby molten glass was poured onto a flat table and spread over it to the thickness required, then placed in an annealing oven. After the glass was annealed it was ground with sand and water and polished with powdered emery. Plate glass was of a sufficient quality and size for mirrors and photographic purposes.

Patent Plate Glass evolved from Broad sheet glass. Patent plate glass was lighter and produced from cylinder glass that had been polished via the same method as plate glass. James Timmins Chance was full partner in the Chance Brothers' Glassworks, producers of crown glass, and plate glass by the cylinder process. His first achievement was to design the machinery to grind and polish sheet glass, which made the firm's glass exceed all others in brilliance and transparency. By May 1841, with the aid of the new machines, the company was turning out more than 4,000 feet of glass per week to meet the enormous demand for the new, patent plate glass. One of the first orders that Chance supervised was 28,000 feet of glass supplied to glaze the Houses of Parliament.

Colored glass, also known as *Ruby glass*, was produced in a number of ways. Metals could be added to the chemistry to produce vibrant colors: such as gold or copper to produce red or manganese to produce amethyst ruby glasses, both used in the ambrotype processes. Colored glass could also be made by flashing; the application of a thin veneer of colored glass, or by coating a sheet of clear glass with collodion or gelatin containing dye colorants.

Opal glass, also known as *Milk glass*, is a white, translucent glass used in the production of opalotypes. There were hundreds of formulas for the production of opal glass, but Tin or Zinc oxides (TiO_2 or ZnO), lead arsenate [$\text{Pb}_3(\text{AsO}_4)_2$] and phosphates were among the most prevalent ingredients used to produce white opaque glassⁱ. There were two varieties of opal glass available: "pot" or "pot metal" and "flashed". Pot opal is white throughout the body of the glass, while flashed opal glass has a layer of white opal glass "flashed" onto clear sheet glass. "Patent plate opal" glass was produced by J. A. Forrest in the 1860'sⁱⁱ.

NEW LIST OF
PRICES FOR PHOTOGRAPHIC GLASS.
R. METTAM,
30, PRINCE'S STREET, SOHO (OPPOSITE ST. ANNE'S CHURCH), LONDON, W.

	POLISHED SHEET.	CRYSTAL SHEET.	BLACK.	FLATTED CROWN.	PATENT PLATE.
	S. D.	S. D.	S. D.	S. D.	S. D.
2½ × 2	0 2	0 3	0 6	0 3	0 7
3½ × 2½	0 3	0 5	0 9	0 5	1 0
4½ × 3½	0 5	0 7	1 2	0 7	1 7
5 × 4	0 7	0 10	1 8	0 10	2 3
6½ × 4½	0 10	1 4	2 6	1 4	3 6

per dozen.

In introducing the above List of Prices to the notice of the Trade, R. M. begs to call particular attention to his CRYSTAL WHITE SHEET GLASS, which for purity of colour and evenness of surface is unequalled: and also to a new article, the POLISHED SHEET, which though not quite so good in colour as the Crystal, is equal to it in quality and surface. Price Lists forwarded post free, on application as above.
February 1st, 1857.

Figure 1. An 1857 advertisement for plate glass.

The above, Figure 1. **An 1857 advertisement for plate glass.** is intended to give the reader an idea of the costs involved with obtaining glass for photographic purposes. The glass in the third column, "black" would also have been called ruby glass, glass that would have been used in the production of ruby ambrotypes (see below). Flattened crown glass was used as cover glasses in ambrotype and opaltype cases because it was thinner than the other glass available. Patent plate, the most expensive glass, was considered the best glass for photograph supports. It had a clarity and perfect surface that allowed for easier coating and better transparency than the polished sheet glass. For more information, please see the appendix, *glass production*.

Chronology and History

Early Research

In 1816, **Joseph Nicéphore Niépce** (1765-1833) began experimenting on the chemical fixation of photographs made with a camera obscura. The *Heliograph* (from the Greek *helios* meaning sun, and *graphos* meaning writing or drawing). In **1822**, Niépce coated a glass plate with a thin layer of Bitumen of Judea dissolved in lavender oil. He exposed it by direct contact under an engraving of Pope Pius VII. The paper bearing the engraving had been oiled to make the paper nearly transparent. Upon exposure to light, the areas of bitumen shaded by the lines of the engraving remained soft and soluble. The plate was then washed in a mixture of oil of lavender and petroleum. The unhardened portions of the bitumen dissolved away, leaving a clear, fine-lined image. Viewed by transmitted light the image was composed of clear lines in the darker field of asphalt.

Niépce also experimented with bitumen on stone, copper, pewter and zinc plates that could actually be inked for printing. His best printing results, in 1826, used an engraving of the Cardinal Georges d'Amboise. He followed the same bitumen of Judea/oil of lavender process but this time employed a pewter plate in place of the glass one.

During his travel to England, Niépce had met, in Paris, Louis Jacques Mandé Daguerre, painter and decor designer, who had a reputation as a camera obscura specialist. Hoping to shorten the 8 hour exposure time of his Heliograph process, Niépce decided in 1829, to associate Daguerre to his research, and to build a camera obscura giving brighter images. This association did not bring any noticeable progress to the bitumen process; on the other hand, the two partners discovered a new photographic process they called the *Physautotype*.

The photosensitive agent of this process, fine-tuned by Niépce and Daguerre in 1832, was the residue of lavender oil distillation. Lavender oil was heated and evaporated to produce a dry product. Niépce and Daguerre would then dissolve a small amount of this tar in alcohol, and pour the solution on a well-polished silver or glass plate. After the alcohol evaporated, a uniform white deposit remained on the plate. The prepared plate was exposed to light in the camera obscura for about 7 to 8 hours. After exposure, the plate was suspended face down, above a tray holding oil of white petroleum. The fumes of this kerosene were sufficient to develop the image without any further treatment.ⁱⁱⁱ

This process produces positive images directly, since the white deposit remains on the plate at places that were touched by light, while the kerosene fumes render transparent the zones that were not illuminated. Images on these plates can be seen as positive or negative: if the plate is backed with a black material the image will appear as a positive and, when viewed by transmitted light, as a negative.

Albumen on glass

The next development in glass supported photographs would not come until 12 years later with **Sir John Frederick William Herschel's** (1792 – 1871) work. Herschel was a brilliant astronomer, chemist and thinker, who discovered Halley's Comet and made advances in photography – such as hypo and the cyanotype. His interest in photochemistry provided the missing link in many of photography's early experiments by virtue of the fact that he shared his knowledge openly and did not seek patents.

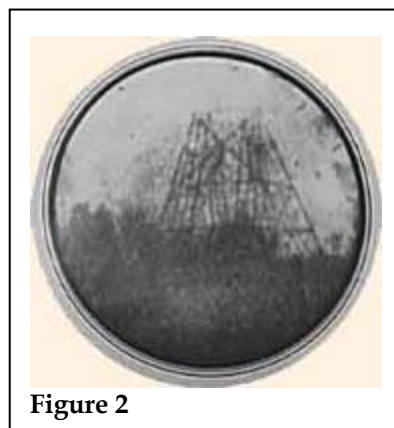


Figure 2

Herschel read of Daguerre's successes with his Daguerreotype process and set out to produce a permanent photograph himself. In **1839**, Herschel succeeded in producing three positive/negative photographs on glass (Figure 2). On September 9, 1839, Herschel photographed his father's 40-foot telescope in Slough, near London. Alexander Stewart Herschel, John Herschel's son, gave a talk to the Photographic society of London in 1872, after this father's death, describing the day the three images were taken and the process involved. After the talk, one of the photographs was broken in half and Herschel suggested that it be used for study.^{iv} The whereabouts of the second plate are unknown, and the third is in the collection of the National Media Museum at Bradford (England). This is the earliest surviving photograph on glass.

In his process, Herschel precipitated a highly diluted solution of sodium chloride and silver nitrate (producing silver chloride) onto a clean glass plate to form a thin coating of silver chloride; a process that took nearly 48 hours. Shortly before exposure, he added more silver nitrate and exposed the plate while it was still wet. The plate was then washed in a dilute chloride solution, then treated with a solution of sodium thiosulfate, which fixed it permanently. The resulting image was a well-defined negative.^v Herschel went on to suggest that "If then the other side of the glass be well smoked and black varnished – the effect much resembles Daguerreotype being dark on white as in nature and also right and left as in nature and as if on polished silver". Furthermore, he noted that if the plate were not smoked and varnished, and the silver coating were thickened by galvanization "there seems no reason why impressions could not be taken from it ad infinitum..."^{vi}

Herschel was modest regarding his findings. In a conversation with Henry Fox Talbot, related by Alexander Stewart Herschel after his father's death^{vii}, John Herschel was said to have commented upon presenting Talbot with one of his photographs on glass, that the process was 'but a step' in the improvement of the photographic process. Talbot replied, after examining the object for a short time, "It is the step of a giant!" Talbot suggested that Herschel call his process the *Amphitype* (from the Greek for "on both sides"), or perhaps Allotype^{viii} based on a derivation of the Greek word for "to

change". While Herschel did not wish to market his discovery, he did go on to use the process rather extensively. This process was painstakingly delicate and time-consuming when compared with other processes of the time. It was practiced and improved upon by a few photographers – such as Robert Hunt and Hippolyte Bayard, who praised the process for its clarity and detail^{ix}.

In 1840, William Henry Fox Talbot conducted some experiments involving albumen on glass fumed with iodine and sensitized with silver nitrate. He first coated the plate with albumen and silver, then after, coating it with a layer of albumen and ferrous iodide, dipped it again in a silver bath. The plate was extremely sensitive and could freeze the image of a rapidly rotating disk that was instantaneously exposed by the light of an electric spark.^x He patented his modifications of the albumen-on-glass process in 1849 and again in 1851; thereby stymieing the advancement of the process, and any other process involving albumen-on-glass, in England. (He also tried several combinations and variations—including albumen salted with potassium iodide. Evidently those efforts did not have enough success to warrant publication.^{xi})

John Adams Whipple (1823 – 1891) began his experiments into glass supports for photography in Boston in **1844**. With his partner, William B. Jones, he was determined that glass could be a workable support for photographs, as he was very dissatisfied with the imperfections that resulted from the use of paper negatives. After many failed attempts with "...milk [and] various other substances of a gelatinous and albuminous [sic] nature..."^{xii} he determined that albumen was the most promising binder. When sensitized with silver iodide and fixed with hyposulfite of soda an image was obtained. However, the image was contrasted in the extreme, with almost no middle tones.

Whipple and Jones continued experimenting with this process, but became distracted by Whipple's work with microscopic daguerreotype images, and in 1847 Niépce de Saint Victor in France announced his albumen process to the world (see below). Being preempted in this manner caused Whipple to scramble for a patent in the United States, but it was not until 1850 that he obtained his patent for the *Crystalotype* (Patent Number 7,458)^{xiii}. This patent covered the use of glass, or another transparent medium, as the carrier for a binder (he suggests albumen and honey for faster exposures), to make negatives on glass, from which paper or glass prints might be produced. Whipple later used the term crystalotype to cover any process that originated in a photograph on glass (e.g., salt or albumen print made from an albumen negative).

In 1853, Whipple sold the rights to the albumen negative process to James E. McClees of Philadelphia, and graduated to using collodion negatives to produce crystalotypes.^{xiv} The use of the process did not cease with its sale to McClees, who perfected the process and marketed it extensively in the United States and Europe. As late as 1858, the process was the one recommended to amateurs for outdoor photography, and in 1885, Charles Ehrmann gave what is apparently the only recorded

description of the process in a lecture to the Photographic Section of the American Institute.^{xv}

In 1847, **Claude Felix Abel Niépce de Saint-Victor** (1805 – 1870), a chemist (and cousin of Nicéphore Niépce) introduced the first practical photographic process on glass. In October of that year, Niépce de Saint-Victor published an account of his experiments utilizing starch on glass in the *Compte Rendu des Séances de l'Académie des Sciences*. The process relied on sensitization with silver iodide and development with hot gallic acid with small amounts of aceto-nitrate of silver. He acknowledged at the end of the article that albumen was a superior binder; while it required longer exposure time (35 seconds for starch, and 5-15 minutes for albumen) it had highly superior resolution.^{xvi}

Niépce appeared before the Academy of Sciences in Paris to announce his new process, called the *Niepceotype*, using glass plates coated with an emulsion of potassium iodide suspended in albumen (Figure 3). After exposure, the plate was developed in gallic acid. The process could be done wet, (for a faster exposure), or dry. While the process was slow, with an exposure time of 5 to 15 minutes, the plates had very high resolution and were used for architectural photography and lanternslides. During the French revolution of 1848, rioters entered Niépce de Saint-Victor's laboratory and destroyed everything. This delayed the adoption of the French process and gave Whipple the opportunity to improve upon his own.



In 1847, **Louis Désiré Blanquart-Evrard**, a cloth merchant from Lille, France, announced a process similar to Niépce's albumen-on-glass. He noted that silver-iodized albumen could be exposed wet or dry and introduced the *amphitype* process, a predecessor to the ambrotype. Blanquart-Evrard underexposed a Niepceotype and placed it upon a dark background. When viewed through the coated side, the product showed as a positive, and from the back of the glass, a negative.^{xvii} The Robertson

album in the George Eastman House archives gives splendid examples of prints made from albumen negatives.

At the same time that Whipple was scrambling to patent his albumen-on-glass process, **Frederick** (1809 – 1879) and **William** (1807 – 1874) **Langenheim** of Philadelphia were working on their own method of producing photographs by means of albumen-on-glass. While Whipple's patent applied to the production of paper photographs made from albumen negatives, the Langenheim process applied to the production of positive glass transparencies from albumen negatives.

In 1848, the brothers made positive transparencies using albumen. They copied daguerreotypes by the albumen negative process (Figure 4) and then contact printed onto a second sensitized albumen plate. Then the second plate was developed, fixed and washed, the image was positive when viewed by transmitted light (Figure 5). This final positive image, called the *Hyalotype* ("hyalo" from the Greek for glass) was applied to the production of Lanternslides and stereographic images, and patented in **1850** by Frederick Langenheim (Figure 6), patent Number 7,784. This patent covered the use of transparent or frosted glass, or any semi-transparent substance, to make a positive upon glass, for viewing with transmitted light, standardized at 3.5" x 4". Eventually, the brothers also produced stereoscopic transparencies on glass: in 1860, Frederick Langenheim was listed as "stereoscopes", at 722 Chestnut Street,^{xviii} and in their 1861 catalogue they are called the American Stereoscopic Company.



Figure 4



Figure 5



Figure 6



b. Digitally inverted representation

Hyalotypes were the first photographically based lanternslides that were often tinted with transparent colors to enhance the effect on the screen. Before the Hyalotype, lanternslides were merely hand-painted images on glass. By using a negative to print onto another sheet of glass, the Langenheims were able to create a transparent positive image, suitable for projection (Figure 7). Used in "Magic Lanterns" the image was projected onto a screen. This new method became extremely popular and the Langenheims' business increased after their process won a medal at the 1851 Crystal Palace Exposition in London.



Figure 7



b. GEH 1982:2291:0001. W and F. Langenheim, Stolzenfels Rhine, 1856. Verso, reflected light.

Many other companies followed suit and began producing Lantern slides by the albumen on glass process, and after a short period, switched to wet-collodion plates. The introduction of dry plate processes, as well as mass-produced lantern slide kits, made the slides easier for amateur photographers to produce and also made them more accessible to schools and universities.^{xix}

There were two methods for producing the positive transparencies: either by contact printing or in-camera. Contact printing required that the negative be the same size as the desired transparency (3.5 x 4 inches). If this were not possible, the in-camera method would be used: the negative and the glass were both placed in a camera with a long bed and bellows and printing was done by exposure to light. After development and drying, the plate could be hand-colored using transparent tints (Figure 8). The method of mounting preferred by Langenheim was to cut the positive and the cover glass into a circle and insert this into a wooden frame of a size to fit the lantern. A more general method of mounting was to cut the positive and cover glass to square, with a spacer in between, and fasten the edges with thin strips of black muslin or paper, using bookbinder's flour paste^{xx}. The slide could then be inserted into in a lanternslide projector and viewed on a flat, light colored surface. The light source in the first projectors were oil lamps, and by 1870 limelight was produced by burning oxygen and hydrogen on a pellet of lime.^{xxi} In the 1890's the carbon arc lamp and then electric light was used.



Figure 8

In 1851, Claude-Marie Ferrier (1811 – 1889), an early French photographer who recorded the items shown at the 1851 Crystal Palace Exhibition, introduced a

modification of the Langenheims Hyalotype process to Paris: stereoscopic albumen-on-glass positives. Ferrier went into partnership with Charles Soulier and in 1859 they opened a business in Paris to sell albumen-on-glass stereo views, published under the name "Ferrier et Soulier". They went on to become among the leading landscape photographers in Europe and by 1864 their catalogue offered a large selection of views of Paris, France, and foreign countries including Norway, Russia and Japan.^{xxii}



Figure 9

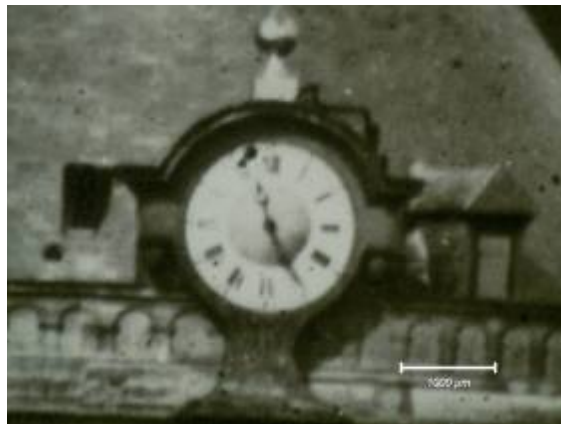


Figure b

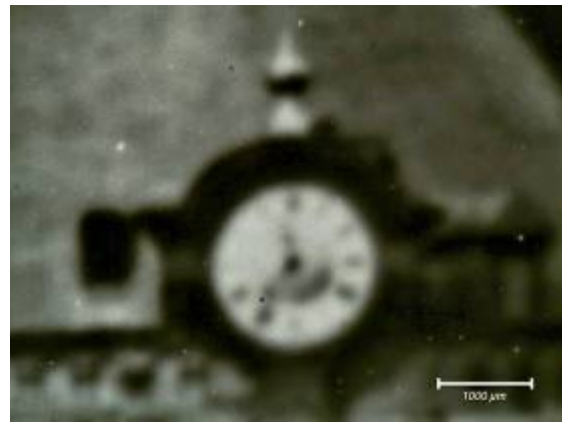


Figure c

Figure 9, *Saint Eustache* in Paris, by Ferrier and Soulier, contains an interesting illustration as to how a stereo transparency was taken. Figures b and c are of the clock in the right central edges of the two images in figure a. Figure b was taken at 11:25 am and figure c was taken at 11:37 am: 12 minutes apart. These observations show that the plate was produced by making the exposure on the right (b), then moving the camera and taking the second exposure on the left (c), 12 minutes later. The fact that the second exposure is slightly out of focus is because the camera was jarred during the shifting of the camera and not refocused. In addition, the figures on the street are different, a carriage has disappeared and people have congregated between the two exposures. By the 1910's, stereo photographs were taken with a dual lens camera that allowed both exposures to be taken at the same time.

In 1854, the Langenheims began producing stereo transparencies by their albumen process. The plates were mounted with a ground glass backing and often featured subtle hand tinting. Single sides were made available for use as lanternslides.

Woodburytype, Carbon and collodion bases were also used in the production of lanternslides (Figure 10) and stereoscopic plates. The three processes can be difficult to distinguish from each other.

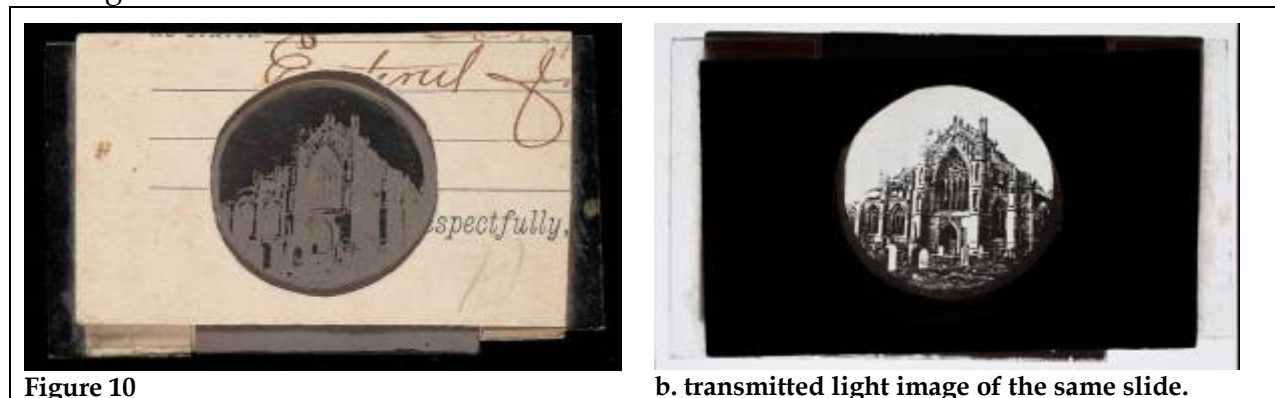


Figure 10

b. transmitted light image of the same slide.

The *Carbon* process had many fathers. It was theorized by **Alphonse Louis Poitevin** (1819 – 1892), and improved upon by many others in the following years, most notably **John Pouncy** (ca.1820 – 1894), **C.J. Burnett**, **Adolphe Fargier** and **(Sir) Joseph William Swan** (1828 – 1914). In 1855, Poitevin patented his observations of the effect of light upon chromated gelatin mixed with pigment, titled “Improved photographic engraving” (BP No.2816)^{xxiii}. J. Pouncy produced the first carbon prints, and patented the process, titled “Improvements in the production of Photographic pictures” in 1858 (BP No. 780)^{xxiv}. These early versions were unsatisfactory in their poor rendition of half-tones, and J.C. Burnett and A. Fargier made further improvements in 1858 and 1860, respectively. However, it was J.W. Swan’s 1864 patented carbon tissue, titled “Improvements in photography” (BP No.503)^{xxv}, which made the process practical for photographers.^{xxvi}

A carbon pigment is suspended in gelatin and sensitized with potassium bichromate, which hardens upon exposure to light. After exposure of the sensitized carbon under a negative, the portions that have not been hardened were washed away in a warm water bath, resulting in a positive image. The Carbon process (Figure 11) produced a continuous tone image because of the proportional hardening of the potassium bichromate upon exposure; the gelatin hardened from the top down, with the degree of exposure determining the depth of hardening. This “tissue” (the common term for the film of emulsion on the paper) was then transferred to another medium such as, in the case of lanternslides and stereoscopic plates, glass, and washed in warm water to remove the unhardened gelatin. The early experiments of Poitevin and Pouncy produced such poor half tones because they did not do this transfer and were therefore removing the unhardened portions of gelatin through the intermediate areas. The image in this case would be laterally reversed. To remedy this, another transfer could be done onto a third and final support. The final image had thicker and thinner areas of pigmented gelatin, depending upon the degree of exposure, and therefore a relief, that aids in separating this process from other binders, such as collodion.

Suppliers such as the Autotype Company in England supplied 30 different colors of tissue.

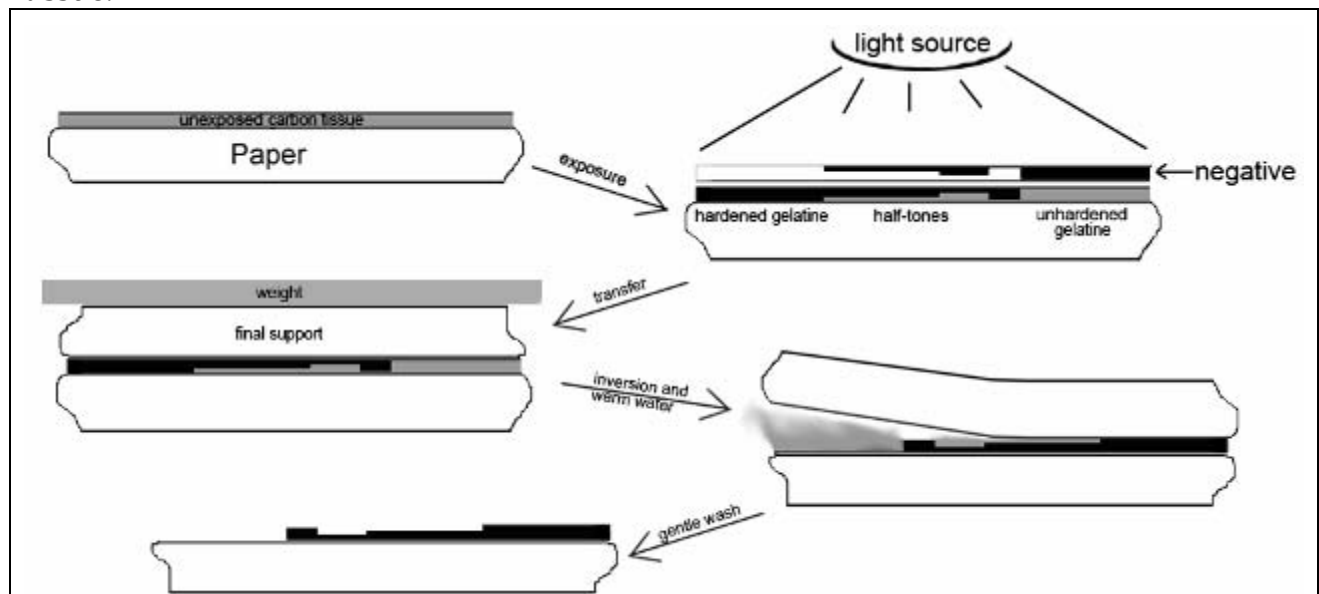


Figure 11



a. The exposed tissue is under pressure with the transfer sheet.



b. After transfer of the carbon tissue. The unhardened gelatin is being removed in warm water.



c. Photograph taken under specular light to show the relief indicative of the process.

Another process used in the production of Lanternslides was patented by **Alexander Melville Clark**, in communication with **Claude Léon Lambert** in 1874 (BP no.3633)^{xxvii}. The patent described 'Improvements in Producing Carbon Photographs', and included details of his Contretype process. In this process, a copy negative is produced by coating a glass plate with gelatin and sensitizing it with potassium bichromate. After drying, it is then exposed under a negative. After exposure, the plate is soaked in India ink – any unhardened sections of the gelatin absorb the color.^{xxviii}

The *Woodburytype* process was patented by **Walter Bentley Woodbury** (1834 – 1885) in 1864 (BP No. 2338) and perfected in 1866 (BP No.1918)^{xxix}. In this photomechanical process, based on Poitevin's carbon process, an intaglio lead mold is made from a relief image (matrix) that has been obtained with bichromated (hardened) gelatin, in a hydraulic press, under very high pressure. This mold is then inked with colored gelatin and the image printed onto the final support. A modification of the process, published later, BP No.3760, 1879^{xxx}, was called the *Stannotype*. It did not

require the expensive hydraulic press. Woodbury himself gave perhaps the most concise description of the Woodburytype process:

“The production of pictures, wither [sic] on white paper, upon glass as transparencies, opal, etc., by this method of printing is based on the principle that layers of any semi-transparent material seen against a light ground produce different degrees of light and shade, according to their thickness, as the carbon process, for example.”^{xxx}

The salient feature of the Woodburytype process was that it made relatively simple the production of glass lantern slides of very high quality in large quantities. Once the matrix was formed, copies could be created by inking the mold with colored gelatin and printing onto another support, rather than having to work with the chemistries and slow printing times involved with albumen printing, or the grain of a half-tone screen. In the 1890's the process was replaced by lower quality, but also lower cost, photomechanical reproductions.

Wet-plate Collodion on Glass

Frederick Scott Archer (1813 – 1857), the inventor of the collodion wet-plate process, was orphaned as a child and apprenticed out to a bullion dealer as a boy. He eventually became a coin appraiser, with a special interest in the portraiture involved. This led him to sculpture and then photography. Intending to improve the collotype printing process^{xxxii} (*collo*, from the Greek word for glue) by using collodion as a binder, Archer developed the wet collodion process. He initially intended to use glass as a temporary support for transferring collodion onto paper. In this process, a glass plate is coated with iodized collodion and exposed while still wet, then developed in pyrogallic acid. Dr. Hugh W. Diamond and Morgan Brown were close confidants of Archer and accompanied him on many of his photographic outings. In an 1875 article about the life of Archer, Brown contributed notes concerning his experiences with the man:

“My desire to know something of photography... induced Dr. Diamond to ask Archer to meet me at Wandsworth Asylum on Michaelmas Day, 1850. There Archer brought some collodion in a bottle and some solution of silver... [Archer] poured the collodion on a piece of glass about three by four inches, sensitized it in the nitrate of silver... put a picture of a house in front on it, exposed it, and developed it into a picture, the film being detached from the glass, and subsequently placed it for preservation between two pieces of glass.”^{xxxiii}

Archer also made a collodion picture in a camera that day, described by Brown as a “faint image of a tree”, but Brown admits to having lost the images or given them to Dr. Diamond. At that point, Archer did not intend to create a new process. He desired to improve upon the calotype process by using collodion, but he could not get the collodion to stick to the paper. That was not accomplished until the invention of the porcelain, and subsequent Leptographic papers. Porcelain papers had a sub coating of white clay or baryta mixed with gelatin, which was then fed through heavy polished metal rollers to impart a china-like finish. In 1870 Jean Laurent and Jose Martinez in Madrid, Spain created leptographic papers by coating porcelain paper with collodion-chloride emulsions.

Archer apparently spent the autumn of 1850 creating collodion plates, honing his process. In March of 1851, Archer published his findings in *The Chemist*, where he discussed the advantages of collodion and offered detailed instructions on the process. In 1854, he published his manual on the process *The Collodion Process on glass*. In it, he discusses the varieties of glass and how to choose the proper type. **Gustave le Gray** and **RJ Bingham** both made claims to the invention of the process, but never published workable formulas.



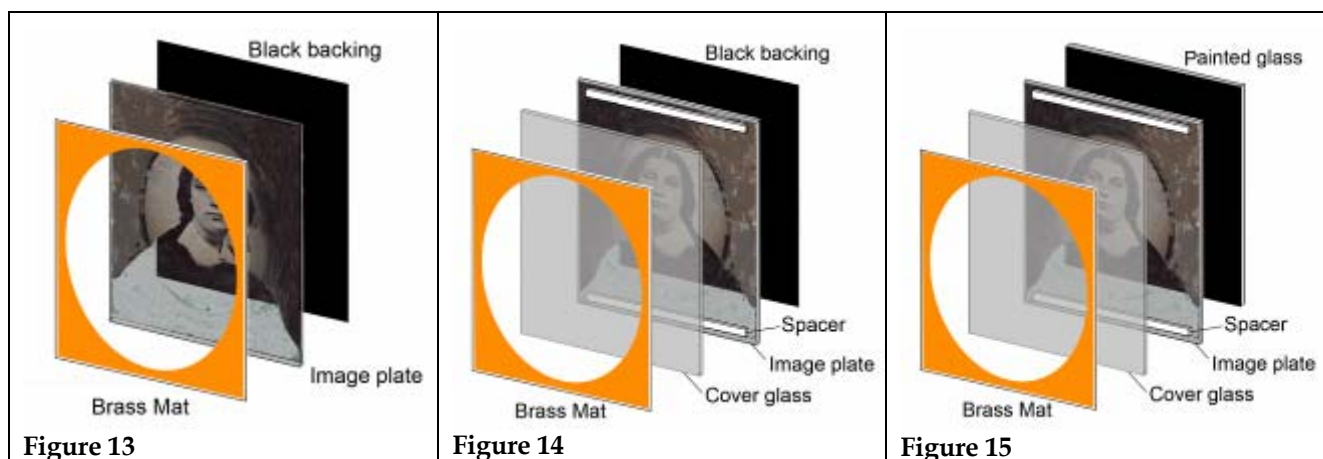
Figure 12

Regardless, Archer was the first to publish a workable formula and make it available to the public. Figure 12 is a print from one of Archer's series of negatives taken at Kenilworth Castle in 1851.

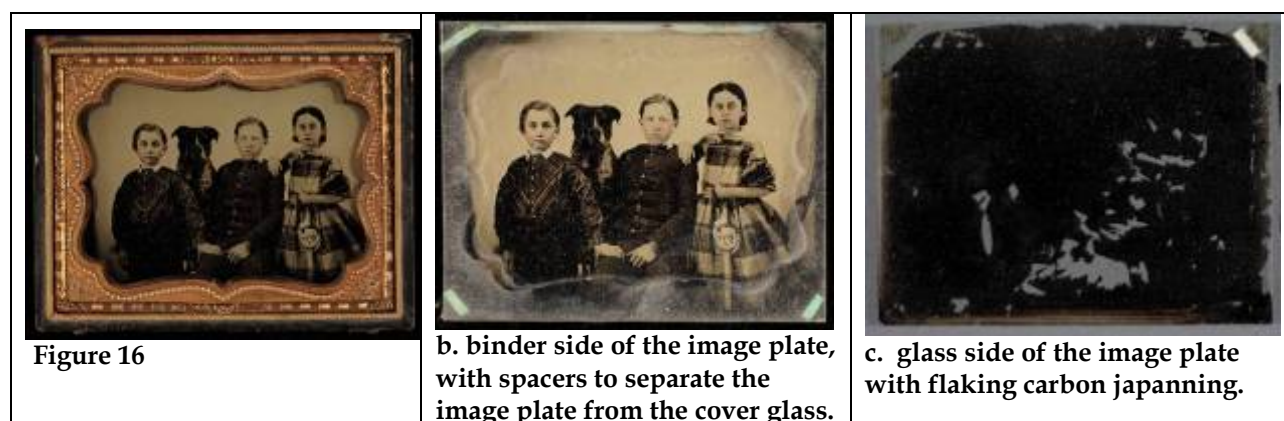
Archer also established a *collodion positive on glass*, or *alabastrine*, process in 1851 (later known as the ambrotype process), in collaboration with Peter Witkins Fry (1772 - 1860), a lawyer, amateur photographer and a founding Council member of the Photographic Society of London.. Coincidentally, Fry was the solicitor for the defense in the patent infringement case Talbot vs. Laroche in 1854^{xxxiv} that contended that the collodion process infringed upon Talbot's calotype patent. The process quickly supplanted the daguerreotype as the portrait method of choice. It was inexpensive and therefore, available to the masses, not just the moneyed class. By 1852, photographers in London were promoting the process as something "any person can produce in a few seconds, at a trifling expense, truly life-like portraits."^{xxxv} The plate sizes followed the Daguerreotype designations^{xxxvi}:

<u>Designation</u>	<u>Inches</u>	<u>Centimeters</u>
Whole	6 ½ x 8 ½	16.5 x 21.5
Half	4 ¼ x 6 ½	10.5 x 16.5
Quarter	3 ¼ x 4 ¼	8.3 x 10.5
One-sixth	2 ¾ x 3 ¼	7.0 x 8.3
One-eighth	2 ⅛ x 3 ¼	5.3 x 8.3
One-sixteenth	1 ⅝ x 2 ⅛	4.0 x 5.3

Collodion positives on glass were made by underexposing wet plate collodion negatives. The silver particles of collodion plates are extremely small, and therefore are seen in reflected light as a brown color. Archer's alabastrines were developed in Pyrogalllic acid and were very dark. They required bleaching with mercuric chloride to whiten the highlights. Later, collodion positives were developed with iron sulfate, which produced a light gray or creamy tan image, that did not require bleaching. When backed with a black material such as fabric, paper or a painted on carbon or asphalt paint historically called 'Japanning', the strongest milky-brown tones of the plates correspond to the highlight areas of the image and the darkest tones are clear glass. The collodion side of the plate would also be varnished with a mixture of a gum or resin, such as sandarac, shellac or Canada balsam, in a solvent, such as water, alcohol, or turpentine. There were also many commercially available varnishes for photographic use. Sometimes light tinting with powdered pigments would be applied on the binder side of the plate to the cheeks of the sitter, or even the clothing and scenery (see Figure 20).



The finished plate would then be covered with an equal sized piece of clear crown glass, with spacers added so that the two were not in direct contact. This is commonly called a *double-glass* ambrotype (Figure 14). The glass side of the plate would be backed with black material, such as paper or fabric, or a black japanning paint, consisting of asphalt or carbon in a binder, would be applied directly to the glass. A brass preserver would be wrapped around the sandwich to make a package. All this would then be placed in a case (Figure 16). There were variations on the construction of the image pack as well: if the photographer decided not to apply the japanning to the image plate, he could apply it to a second sheet of backing glass. These ambrotypes are commonly referred to as *triple-glass* ambrotypes (Figure 15). A *single-glass* ambrotype would not have a separate cover glass and the plate was simply inverted in the package so that the glass side of the image plate acts as the outer surface (Figure 13). The image plate could be japanned on the collodion side of the plate; the plate might not be varnished, a lack that inevitably lead to tarnishing and image loss; or black paper may have been glued directly to the back of the plate to create the positive.



When the collodion positive process hit the market in the mid-1850's it was quickly accepted by the public. The faster exposure times, coupled with the ease of viewing, allowed the process to replace the Daguerreotype as the popular studio portrait technique. At this time, the process was recognized by a number of different

names: *collodion-positive*, *daguerreotype-on-glass*, *daguerreotype-without-reflection*, and in Europe, either *verreotypes* (*verre* is the French word for glass, from the Latin *vitrum*), or *amphitype* (from Greek, for *amphi* meaning on both sides).

The term *ambrotype* first appears in **James Ambrose (Anson) Cutting's** (- 1865) 1854 English patent (No.1638)^{xxxvii}. Legend has it that the name ambrotype came from Cutting's middle name, but, it is known that he had his middle name changed from Anson to Ambrose when he patented the process, to make the name seem serendipitous^{xxxviii}. His particular method of production was to seal the collodion binder against another sheet of glass with Canada Balsam, a process that had been known in the manufacture of microscopic slides. (Figure 17) To accomplish this, a line of heated Canada balsam was laid along one edge of the cover glass and the image plate was aligned, then slowly laid down, pressing out the excess balsam and air bubbles. This package would then be sealed with paper tape around the perimeter and fitted into a case. If the name 'ambrotype' were to be taken literally (*ambrotos*, from the Greek for imperishable), then this method produces the only true ambrotype. The sealing of the image binder against another sheet of glass makes the image highly resistant to adverse atmospheric and environmental conditions.

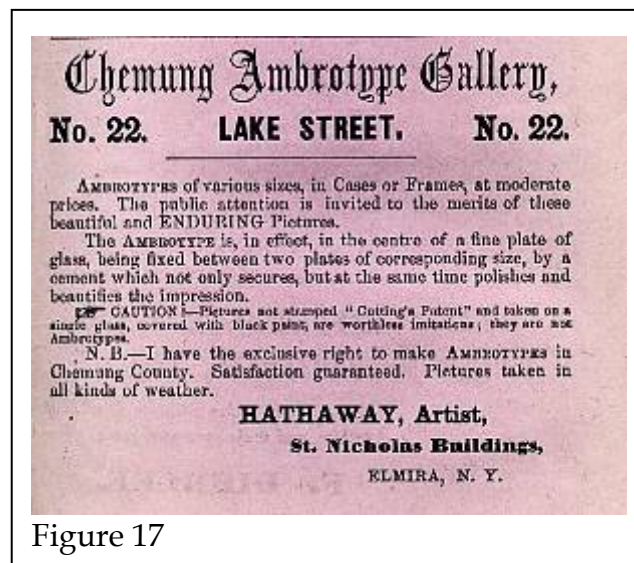


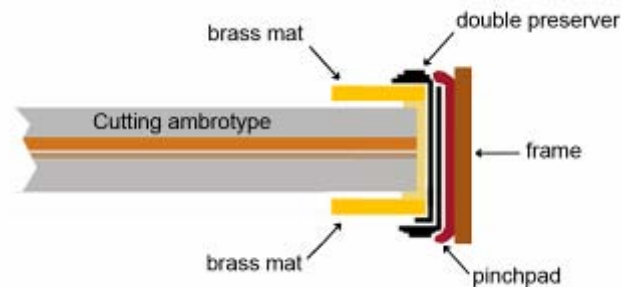
Figure 17

An interesting feature of the Cutting ambrotype is that it inspired the creation of a different variety of case. Figure 18 is an example of a 'double hinged' case. The sealed nature of the ambrotype serves to protect the image binder to such a degree that this case was created, presumably, to allow the viewer to see a proper backwards, or alternatively, a transparent view of the plate. It is interesting to note that this case allowed for two views of the sitter: one that showed the sitter as he saw himself in a mirror (the only way people saw themselves at the time), and therefore a more familiar view and another, "proper view", that showed how the rest of the world saw the sitter. It is uncertain where these cases originated, but the photographer Mathew Brady produced so many of them that some dealers describe them as 'Brady cases'. Most of

the cases were constructed of leather-covered wood, with finger joints for added stability, and others were made with a steel frame. These cases also required a special kind of double preserver to hold the plate-package together while maintaining the aesthetics of both sides of the package (Figure 18b). Smaller plate-packages were held into the case with the pinchpad, while larger packages required metal tabs to be built into the frame.



Figure 18



b. Cross-section of the double-view Cutting ambrotype image pack construction.

The '*Relievo*' portraits were introduced in England in 1857 by **Thomas C. Lawrence**, a Greenwich photographer.^{xxxix} The '*Relievo*' ambrotype was based on the relief effect that was achieved by the layering of the image plate over another image or background. The structure of a *relievo* ambrotype could have been single, double or triple (see above), depending on the style. Many *relievo* ambrotypes are very simple, with merely a piece of white or light colored card (Figure 19b), or other light material such as foil (Figure 21), placed behind the sitter at the time of exposure. The most simple *relievo* ambrotype was made by placing the subject in front of a white background, to give an even light tone (Figure 20) on the final plate, and then applying blacking behind the sitter on the image (Figure 19b). Other methods included placing the sitter in front of a black background, to give no exposure behind the sitter; or to make the ambrotype in the usual way, and then scraping away the background (Figure 21).

Figure 21 is an example of a more complex *relievo* ambrotype in which a portion of the primary image has been posed on a background. The tree behind the figure was on a second ambrotype layered behind the first, taken from the sketch on the table. The image plate is backed with blacking behind the figure. A secondary image plate or other material is placed behind the image plate and this fact is concealed by the brass mat. Spacers, usually made of cardstock, separated the two from each other.



Figure 19



b. GEH 1995:2607:01



Figure 20



Figure 21



Figure 22

The *Sphereotype* was patented by **Albert Bisbee** in conjunction with **Yearless Day** in 1856 (US patent #14,946). The process involved making the border of the image (ambrotype) transparent, and placing the mat behind the image plate with the advantage of protecting the mat and “making the picture appear more round, causing an illusion, as though the picture or image was suspended in the atmosphere clear from the background.” This was accomplished by placing a board inside the camera of “an aperture of any desired pattern that we wish the edges of the picture to have”^{x1}, leaving the shaded portion of the plate clear (

Figure 23c). After processing, blacking is applied behind the figure only (

Figure 23b), and the mat is placed behind the image plate in the plate-package (Figure 24).

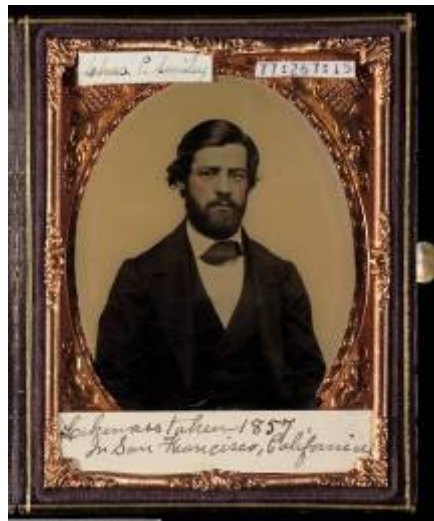
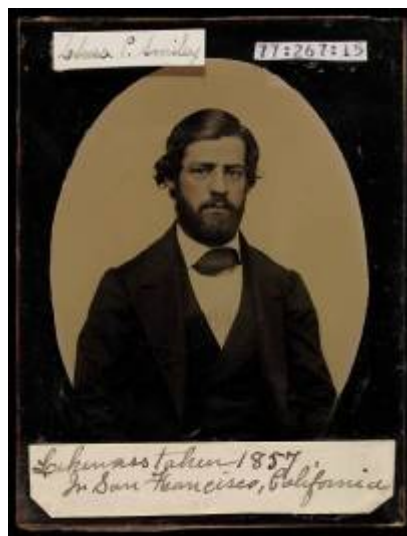


Figure 23



b. Verso of plate package, showing black backing and mat behind image plate.



c. Recto of image plate, against black velvet, showing spherical vignetting of image area.

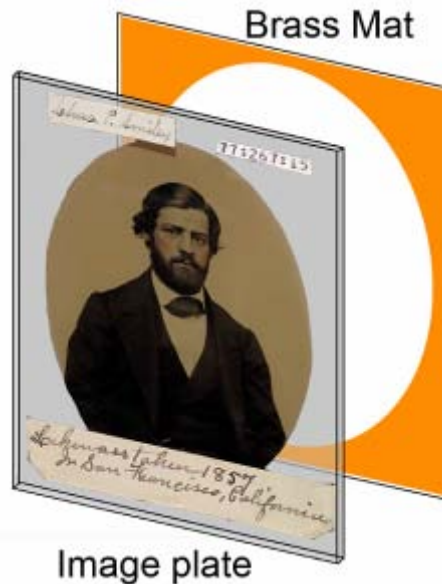


Figure 24

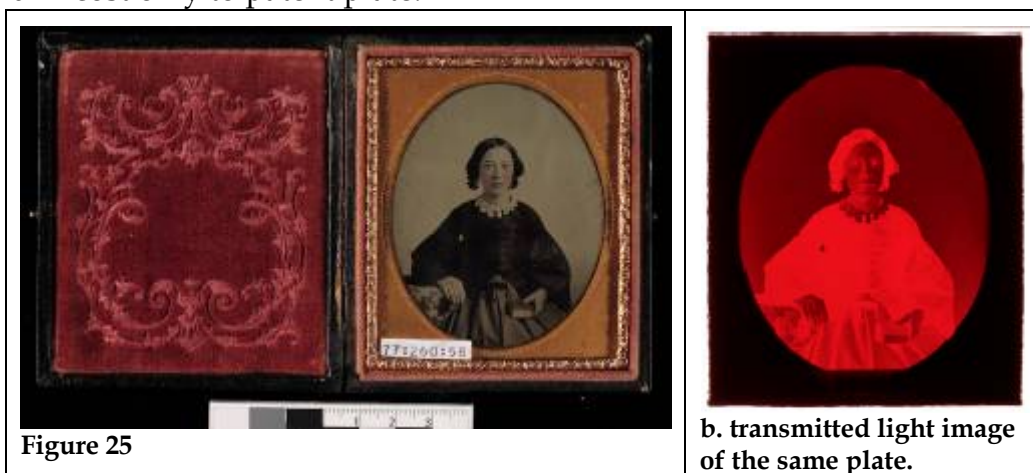
Figure 18 and

Figure 23 are of the same sitter, Mr. Charles P. Smiley of San Francisco, and taken by Robert H. Vance, in 1857. The Sphero-type (*sphere*, relating to the circular image area on the plate) in

Figure 23 has the look of a Sphero-type, but it is not a true one. This plate was probably taken at the same time as the above Cutting ambrotype of Figure 9, but then the emulsion was scraped away to give a pseudo-relievo-Sphero-type look, which was rather popular at the time. A true Sphero-type would have a more indistinct border around the image area. This is being pointed out so that the reader will understand that studios did not always specialize in one type of portrait: they usually offered a variety to suit the sitter's tastes. Another variation of the relievo ambrotype was a rather

American permutation: the sitter was photographed against a white background and backed with blacking behind the sitter to give a small relief effect and a very even background.

Another variation of the ambrotype process is the *ruby-glass-ambrotype* or *rubitype*. The name was taken from the dark glass used as a base for the collodion image. Although the word 'ruby', implying red (Figure 25), was used, and was indeed the most commonly used color, the color of the glass could be of any dark hue: dark red, blue, green, purple (sometimes called *amethyst*), orange, or brown. Ambrotypes on ruby glass were considered higher-end photographs. This was partly because of the cost involved in obtaining the glass, but also because the dark glass support produced blacker shadows in the final image, obviating the need for dark paper backing or japanning, which were subject to deterioration or flaking. Companies that sold the glass to photographers would list it as 'black' glass and attached a higher price to the material. Figure 1, on page 1, depicts a 1857 advertisement^{xli}. Note that the 'black' glass is second in cost only to patent plate.




As with any photographic discovery, there are imitators and innovators. The Cutting ambrotype had many imitators. Some that used inferior materials or colored glass as a backing, and others that created what appeared to be an entirely new process. The *Chromo-crystal* was introduced to London by **Thomas Skaife** in a letter to the *Brighton Herald* in 1859.^{xlii} A small collodion plate was exposed in Skaife's patented (BP No. 1373) Pistolgraph camera, with his patented (BP No. 2939) flash mechanism. The resulting plate measured approximately 6.7 x 3.2 cm, with an oval image area measuring approximately 4 x 3 cm (see Figure 27). This would then be cemented with Canada balsam to a piece of ruby glass, approximating the image area, and "baked...over a lamp until the two glasses are so united as not to be separable without breaking".^{xliii} Once finished the "gem" could be trimmed to between "1 ½ to 3/8 of an inch in diameter after they are trimmed by the lapidary. They are the neatest and best-executed portraits... suitable for mounting in bracelets, brooches, pins or rings"^{xliv} (Figure 26). Skaife claimed that the sealing with balsam and subsequent heating was the best way to preserve the image, even going so far as to claim it could not be

damaged. This attribute is probably more likely a function of the physics involved in separating two small pieces of glass that are well cemented together, rather than the heating.

A more popular use for the tiny plates was to print them onto small calling cards. These photographs were called *pistolgrams* after his Pistolgraph camera. The tiny size of the image plate and camera lens resulted in “instantaneous” photographs (about 1/15 sec. exposure), and the technique was marketed for images of babies and pets. Skaife was also known to take portraits of equestrians in Hyde Park “in all phases of motion”^{xliv}, and exhibit them in his near-by Baker Street studio in London.

CHROMO-CRYSTAL PORTRAITS
FOR BRACELETS, &c.,



TAKEN WITH
SKAIFE'S PATENT PISTOLGRAPH.

	£	s.	d.
Equestrian or other Portrait	-	-	1 1 0
Two Portraits in one Picture	-	-	1 11 6
Group of Three	-	-	2 2 0
*Portraits Copied	-	-	0 10 6
Additional Copy	-	-	0 5 0

Families attended at their own residences, and Lessons on the Pistolgraph given to Amateurs. Terms supplied on application to the Patentee, T. Skaife, Vanburgh House, Blackheath.

—§§—

Selections of Pistolgrams (Chromo-Crystalized), including Portraits of Children, Horses, and favourite Dogs, may be seen at 5, Haymarket, London, and the Medical Hall, East Street, Brighton.

—§§—

* “When a valuable portrait is in danger of being effaced by the chemical action of the atmosphere, you should get it Chromo-crystalized, a process which includes taking a small copy by Skaife's Pistolgraph, enclosing it between two plates of glass of dissimilar color, and baking it therein until picture and glass become one hard, homogenous substance, as durable as a painting in enamel, and capable of being cut by the lapidary into any shape the jeweller may require.”—*Brighton Gazette*.

[CUTTING AND SON, PRINTERS, GAZETTE OFFICE, BRIGHTON.]

Figure 26



Figure 27



b. verso



c. transmitted light

Opal types, also known as Opalotypes or Milk-glass positives, were produced from 1860 until the 1940's. The process was patented by **Joseph Glover** and **John Bold the younger** in 1857 (BP No. 501). This patent covered the use of “Enamelled glass, minerals or other suitable mineral substances” that were washed first with fluoric acid to etch the surface and prepare it to receive “the collodion or other sensitive substance”, and exposed through a negative. They went on to describe how the finished photograph could then be tinted (Figure 28) with “water colors, oil colors, dry colors, and varnish colors.”^{xlvi} Other variations on the process included, grinding down the

glass slightly with fine emery powder, or the application of a matte varnish, to increase the adhesion of the binder layer to the glass^{xlvi}. The light sensitive binder could be gelatin, albumen, collodion, or carbon transfer – the point being that the opaltype took advantage of all of the variations of the various binders. Very often, opatypes would be housed in brass frames or cases similar to those used to house ambrotypes (Figure 29).



Figure 28



Figure 29

The term “opaltype” became common for the process by mid-1860, although, over the years, some variations on the process and interesting nomenclature were introduced. In 1864, the *British Journal of Photography* reported experiments by **Frederick Augustus Wenderoth**, which involved the application of albumen chloride binder to ground pot-opal glass. Wenderoth called his process the *Toovyttype*.^{xlvi} The same article also mentions a **William Helsby** and his collodion iodide variant called, the *Helioartistotypia*, patented in 1865^{xlvi} (BP No. 12).¹

Vitrified photographs on glass are still being produced in some regions of Europe for headstones and other decorative purposes. These permanent photographs have had many new developments in the past 150 years. The roots of this process however, lie in **James A. Forrest's** experiments. He based his work on burnt-in photographs on the observations, made in 1280^{li}, that when salts of silver are laid upon glass and exposed to 750°C a transparent yellow tone will result. In Forrest's process, a collodion positive on glass was coated with a flux mixture of very finely ground flint glass, pearl ash, borax, red lead and chloride of sodium. When dry, this is exposed to 750°C in a kiln for about three minutes. He suggested the use of porcelain, opal or clear glass. At a meeting of the Liverpool Photographic Society in 1857, Forrest showed specimens from his experiments. These consisted of photographs seen by reflected light with a dark background, and transparencies for hall lamps and windows.^{lii}

In 1862, **Ferdinand Jean Joubert de la Ferté**, a French engraver, read a paper at the Meeting of the Photographic Society in London in which he discounted Forrest's

process as too delicate and difficult to reproduce. He stated that in most cases “...although some portion of the silver was retained in a yellow tint on the glass when taken out of the kiln, the greater portion of the photograph has disappeared: for the organic substance of the collodion was burnt off, and left no trace on the glass in many instances.”^{liii}

Joubert called his process *enamel photography* and patented it in 1860 (BP No.149)^{liv}. He coated a piece of crown or “flatted” (cylinder) glass with a mixture of: “bichromate of ammonia in the proportion of five parts, honey and albumen three parts each, well mixed together, and thinned with from twenty to thirty parts of distilled water, the whole carefully filtered before using it.” He advised that this mixture be prepared in a darkened room or under yellow light “so that the sensitiveness of the solution may not be diminished or destroyed”. After drying, this was placed in contact with a diapositive, such as a positive photograph on clear glass or waxed paper, in a printing frame. After exposure, a “faintly indicated” negative was be visible in the sticky coating. This was then brushed with enamel color until the subject appeared as a positive. It was then fixed in an alcohol and acetic acid wash, and submersed in a pan of clean water “and left until the chromic solution has dissolved off, and nothing remains except the enamel color on the glass”. The plate was then dried and fired in a kiln.^{lv}

Joubert was also the first to produce good results from Poitevin’s collotype process. The process was based on the observation that when stone, metal or glass coated with bichromated gelatin, is exposed under a negative and then exposed to water, a greasy substance is formed in proportion to the areas exposed to light. This would then be used to make photographic prints. Joubert called his prints “Phototypes”. He never published his version of the process however, and it never came into common use.

Preserved and Dry Plate Collodion on Glass

A hurdle that photographers needed to cross in collodion photography was the inconvenience of working with the wet-plates. It was cumbersome to have to carry your darkroom around and process immediately after sensitization. Photographers desired a method of preserving the sensitivity of the plates without having to coat, sensitize and develop in the field.

Preserved Collodion Plates

In 1854, George Shadbolt (1830 - 1901) partially succeeded in solving this problem with the introduction of his *honey process* (honey diluted with distilled water) or basically, the discovery of the "Sugar and water" preservative process.^{lvi} The sugar solution acts as a humectant that keeps the sensitized collodion moist and therefore, extends its sensitivity^{lvii}. This process had many permutations such as, the "Sweet Wort process" the "glycerine process", the "Raspberry vinegar" process, and finally, the *Oxymel* process.

An early version of this process, introduced in 1856 by John Dillwyn Llewelyn (1810 - 1882), kept sensitized collodion moist by coating the plates with a medical tonic of honey and vinegar called Oxymel. Plates coated in this manner would retain their qualities for months; however, at the expense of sensitivity.^{lviii} Figure 30, is from a Photographic Exchange Club album in the George Eastman House collection and was taken by Llewelyn with his Oxymel process. The accompanying inscription states: "*And in the weedy moat, the heron fond of solitude alighted. The moping heron motionless and stiff, That on a stone as silently and stilly stood, an apparent sentinel, as if To guard the water-lily... Taken by the Oxymel process, June, 1856; weather dull; exposure twenty minutes; developed with Pyrogallic Acid.*" It may be surmised that the Heron "in its natural surroundings" was in fact a stuffed bird, placed in the pond. Nevertheless, the intention of demonstrating the versatility of the process and its possible outdoor, landscape-photography applications, was accomplished.



Figure 30. GEH 1979:1992:0020
Piscator, No. 2, J.D. Llewelyn

One of the most popular preserved collodion processes was the *Taupenot Process*, introduced by Dr. J. M. Taupenot (1824 - 1856) in 1855, the first practical *dry collodion-albumen process*^{lix}. In this process a collodion plate was prepared using the *Tannin Process*, introduced by Major Russell in the mid 1850's, whereby the collodion plate is washed clean of excess silver while wet, coated with a solution of tannic acid, and allowed to dry. In Russell's process, the coating of tannic acid allowed the plate to be kept in dark storage for months before exposure. Taupenot's process called for an additional coating of iodized albumen and another coating of silver nitrate (thus

providing two sensitive layers). This first dry plate process could be stored for several weeks before exposure. The only drawback to these processes was a greatly increased exposure time (about 6 times longer than the wet collodion process, depending on the storage time).^{lx}

Dry Collodion Plates

The preserved collodion process can be divided into two categories: preserved moist, as previously described, or dry. In both of these processes, a wet collodion plate is sensitized in a silver solution then washed in water, before coating the surface with a humectant as in the case of the Oxymel process, or a siccative, as used in the Tannin process. The Tannin plate had the same sensitivity as an Oxymel plate, but the collodion film was completely dry.

Collodion Emulsion

The separate silver solution was dispensed with when the collodion emulsion process was introduced. Collodion emulsion was made by combining the collodion binder, the halide (iodide, bromide or chloride) and the silver together in the same bottle prior to coating the plate. Collodion emulsions were made as washed or unwashed. Unwashed collodio-chloride emulsions were made for printing-out plates (opaltypes and lantern slides) and printing papers. Washed emulsions were made specifically for negatives and positives on glass.

A “washed emulsion” is one that has been washed of an unwanted compound formed during its making, before the glass plate is coated. When silver is added to the salted collodion, double decomposition occurs whereby the light sensitive salts are formed. For example, when an emulsion is made with potassium bromide and silver nitrate, silver bromide and potassium nitrate are created. While the silver nitrate is required for photosensitivity, the potassium nitrate is not and is removed in a washing step. If it were not removed, it would crystallize and spoil the plate.

Collodion emulsions were washed by pouring the sensitized emulsion into water in a steady stream; this would produce strings of emulsion, rather like spaghetti. This pellicle was then washed for several hours. When the washing was complete, the excess water was squeezed out and the sensitized emulsion could be stored until needed. To emulsify further the sensitized pellicle, equal parts of ether and alcohol were used to dissolve the emulsion, and the plate could then be sensitized.

There is no clear division between collodion and gelatin-glass plate photography: there were many mixed binder processes from 1870 until the turn of the century, and there were many mixed-binder variations on the collodion process available during the collodion era.

Dr. Richard Hill Norris (1831 – 1916) of England, patented a Collodion dry plate process involving gelatin in **1856** (BP No. 2064)^{lxi}. Hill Norris was the first to realize that an important function of the preservative coating on a collodion dry plate was to fill up the pores of the collodion while they were still wet.^{lxii} This was accomplished by

pouring liquid gelatin, albumen, or other similar substance over the wet collodion. Hill Norris patented these plates in September 1856 and went on to manufacture them commercially. Norris Hill's plates were so popular with amateur photographers between 1856 and 1866, that he founded the Patent Dry Collodion Plate Company in Birmingham in 1858. Norris also went on to improve the process, introducing his 'Extra Quick Dry Plates' in 1860.

Gelatin on Glass

The division of washed and unwashed collodion plates can also be applied to gelatin binders. In the washed gelatin emulsion process, a suspension of Silver nitrate, Potassium Bromide and Potassium Iodide is made in a gelatin binder (Figure 31) and allowed to solidify (Figure 32). Once set, the emulsion is “noodled” with a ricer or colander (Figure 33). In the 19th century a piece of open weave canvas would be used to create noodles to make as much surface area as possible for washing.



Figure 31



Figure 32



Figure 33

Noodling and washing is done to remove the excess nitrates and potassium from the Silver nitrate, the Potassium bromide, and the Potassium iodide that was added during the concocting process, leading to Potassium nitrate that will affect the emulsion adversely. Using *cold* water, so the gelatin noodles do not dissolve, the emulsion is washed for about 15 minutes, removing the Potassium nitrate, which will cause fog and reduce filament size if left in the emulsion.

Chloride and Bromide are two of the three halides used in photography (the third being Iodide, the predominant halide in all of the in-camera processes used prior to gelatin plates). Silver chloride was the light sensitive solution used in early printing out processes (POP), such as albumen, collodion chloride and gelatin chloride papers and plates. A printing out process is one that produces an image as the exposure is done, since it converts to gray-black metallic Ag via photo-reduction. Silver bromide is the most sensitive of the silver halides and is found in the developing out processes (DOP). A developed out process requires development of the invisible “latent image”.

By the late 1870's, the preserved collodion processes, and gelatin and collodion emulsions, were being used by advanced amateurs to take photographs without having to take the darkroom into the field. One discovery that made this possible was that as the percent of Bromide was increased the sensitivity of the plates increased, making faster exposures possible (Figure 34). Another advancement that allowed for faster exposure was the progression of alkaline chemical development from physical development. Before the 1870's all development in photography was physical. Acid was used as a restrainer for development and excess or “free” Silver nitrate was

required for the image reaction to occur. The silver particles produced by physical development are tiny, compared to chemically developed silver, and have a distinctive color. Chemical development uses an alkaline and no free silver is required. The result is larger, filamentary silver particles that have a cooler tone, and are much more sensitive, resulting in a faster exposure. The earliest experimental gelatin processes were iodide based and required acid development.

THE "ARCHER"
GELATINO-BROMIDE PLATES.

THESE Plates can with confidence be strongly recommended to the profession as the most sensitive commercial Plates in the Market, combining also every other good quality desirable in a Dry Plate, viz., good body, with density; easy development, with plenty of latitude in exposure; "and are supplied 30 times rapid if required;" and last, but not least, cheapness. These Plates are now made from an entirely new and greatly-improved formula, securing, as well as uniformity, the highest degree of sensitiveness. The prices per dozen are as follow :—

4½ x 3½ - - 2/- | 6½ x 4½ - - 4/6 | 8½ x 6½ - - 8/-
Other sizes equally reasonable in proportion.

To induce Photographers to deal direct with the Maker, a discount of 25 % will be allowed on orders of £2 and upwards, and no charge for packing. To enable Photographers to prove the correctness of the superior qualities of these Plates, a packet of Three quarter plates will be forwarded, post free, for 6 stamps. FREE STUDIO DEMONSTRATIONS any Morning before 1 o'clock to purchasers of Plates to the amount of 2/-.

GELATINO-BROMIDE PELLICLE.

Professional or Amateur Photographers wishing to make their own Plates, and, at the same time, save the tediousness and uncertainty of emulsion making, will find the Pellicle everything desired. All that is necessary is to dissolve the Pellicle in water, filter, and coat the plates. Price, per ounce, 4/6. One ounce of the Pellicle will make twelve to thirteen ounces of emulsion, coating 10 dozen quarter plates. Professionals or Amateurs requiring Formula and Practical Instructions in the Making of Emulsions and Coating Dry Plates can, by arrangement, receive the same at the Factory or full Instructions by Post.

Figure 34

Richard Leach Maddox (1816 – 1902), a physician in **London**, discovered Silver bromide emulsion. In an article in the *British Journal of Photography* on 8 September 1871, he suggested a process whereby the sensitizing chemicals could be coated on a glass plate in a gelatin emulsion, instead of wet collodion. He described how a gelatin emulsion was formed with nitric acid, hydrochloric acid, cadmium bromide and silver nitrate. This was coated upon a glass plate, exposed, and physically developed in a solution of pyrogalllic acid and silver nitrate. The resulting images were "small, delicate, completely detailed brown negatives"^{lxiii}. This was the first commercially viable gelatin emulsion. Maddox was a physician and experimented in photography as a hobby. He had freely made his ideas known, and never patented the process^{lxiv} and as consequence, **John Burgess** and **Richard Kennet** were able to introduce their refinements in 1873.

In 1878, **Charles Harper Bennet**, and others, made the first gelatin dry plates for sale on the open market, a revolutionary advance in the science of photography. Charles Bennet discovered a method of hardening the emulsion, making it more resistant to friction in 1873. This was discovered by cooking (prolonged heating) the gelatin emulsion so that the sensitivity could be greatly increased.

The **Orotone**, also known as D'Oroton (French), Dorotone, goldtone, or Curtistone, is a thin (underexposed) positive image on glass, often with a silver gelatin emulsion and made by contact printing the original negative. The process was prominent from the late 1880's until the 1920's. The use of gold backing was a common specialty practice and every photographer who used it had his own recipe, in particular, the photographer Edward Sheriff Curtis^{lxv} (Figure 35.).

Curtis' Orotones were particularly luminous and the backing material more stable than most^{lxvi}; therefore, he is

credited with perfecting the process in 1916. Curtis' process consisted of backing a gelatin on glass positive with a mixture of banana oil and gold dust. Due to the expense of gold, Curtis developed a technique that substituted brass for gold, and created the "Curtis-tone" process, also known as the Doretype process. These plates were usually housed in special ornate frames.



Figure 35.

Colour processes

The Lippman process, introduced by **Gabriel Lippman** (1845 – 1921) in **1891**, is a natural color plate that relies on interference. It is exposed backwards (thru the glass): just prior to exposure, Mercury is poured on the back of the plate holder, in contact with a fine-grain silver bromide on glass. This forms a mirror and light bounces around in the camera, re-exposing the plate. The final plate looks like a dense negative when viewed by transmitted light, and a color image (Figure 36) when viewed by reflected light and at a certain angle. The process was delicate to perform and difficult to view and did not gain widespread popularity.



Figure 36

There were many color screen processes. The first primary color screen process was the **Joly** process, patented in 1895 by **Charles Jasper Joly** (1864 – 1906). In this process, an orthochromatic gelatin plate is exposed through a screen of alternating lines of red, green and blue-violet (Figure 37). After development, the plate is then bound with another screen of complimentary lines. When viewed by transmitted light, a color image is seen. The process was not very practical and while a color image, it was dark because of the diffusing filter. This process relied on two plates: one with ruled lines of gelatin with dye interface that had a critical alignment. These plates would lose their colour with differing expansion rates of the gelatin layers or glass deterioration, as seen in the large parrot below.

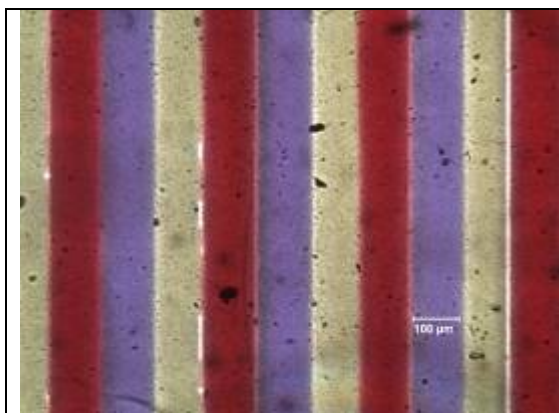


Figure 37



Figure 38

The first popular color process was the Autochrome process, patented in **1903** (FR.Pat.No. 339,223, 1903) by **Auguste** (1864 – 1948) and **Louis** (1862 – 1954) **Lumière** in France (patented in America, June 5, 1906 (No. 822,532)), and marketed in 1907. This process has an integral layered structure that cannot be separated. Therefore many of these plates survive today. The Autochrome (Figure 40) is an additive color 'screen-

plate' process: the media contains a glass plate, overlaying random mosaic of microscopic grains of potato starch dyed red, green and blue, with lampblack filling the space between grains (Figure 39). This screen of grains worked as a light filter to interpret the scene when the light passed through them exposing a black and white, panchromatic silver halide emulsion. Glass (the plates were available in all standard sizes) was coated with liquid pitch mixed with a small percentage of beeswax (to help keep it "tacky") then the prepared grain was dusted on and manipulated with a mechanized stylus. By this very action, the resultant screen was random in nature. In order to produce no exposure on the rest of the plate, not masked with the colored starch grains, it was necessary to fill the spaces between the irregularly shaped grains. Lampblack was used as filler, applied by way of a special machine.

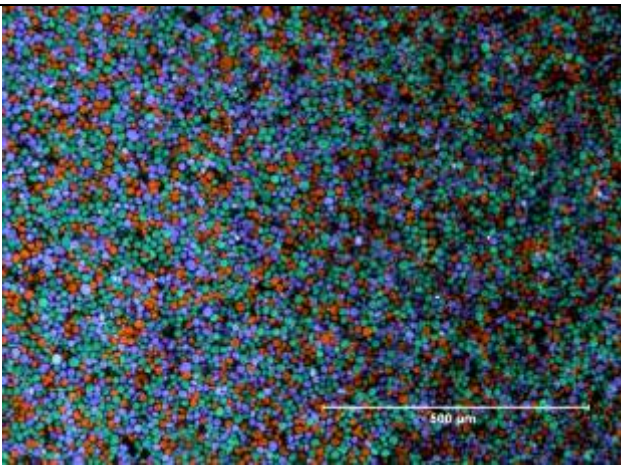


Figure 39



Figure 40

Face mounted prints

Throughout the history of photography there have always been the “Obscurotypes”^{lxvii}, the processes that do not fit comfortably into any one category. The face-mounted prints that were made throughout the history of glass-supported photographs often fall into the obscurotype realm: they come in all shapes and sizes, and are mounted to a variety of materials, usually glass. The following is an attempt to categorize some of the most commonly found face-mounted prints.

The **American Ivorytype** was introduced by **F.A. Wenderoth** in **1859**, consists of a salt print that has been hand-tinted and face-mounted to glass, treated with wax or rosin to make transparent and hand coloured (Figure 41). Sometimes, a second piece of glass or paper backs the image with additional colouring. A similar process, called the **Eburnum** process, was published in the *Photographic News*, on May 15 in 1865 and described by **J.M. Burgess** of Norwich, involved transferring a carbon or collodion binder to a sheet of glass and backed with a zinc-oxide and gelatin mixture to give the impression an ivory backing.



Figure 41

The **Crystoleum** (Figure 42) process was popular from the 1880's until the 1910's, and was usually a albumen print face-mounted to *convex glass* with gum or paste. The paper is then rubbed away with sandpaper until the emulsion layer is exposed. What was left of the paper was made translucent, if needed, with a dry oil, wax or varnish. The fine details were then painted on the back of the photograph, a second piece of convex glass that has been broadly coloured is layered behind the image glass, and the package is bound with a paper backing. There were some prints produced that did not have any colouring and merely consisted of the print face-mounted to a sheet of convex glass.

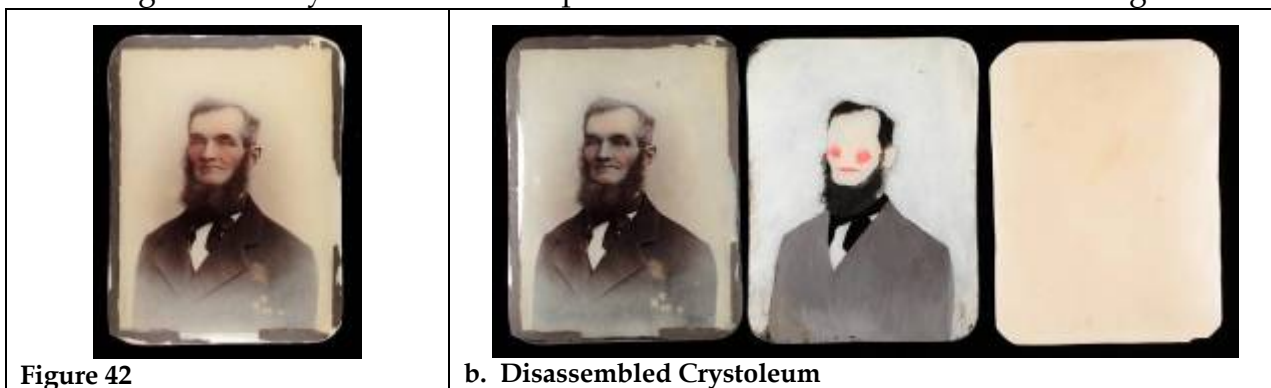


Figure 42

b. Disassembled Crystoleum

Identification Key

How to use the key:

When the user must choose one of two alternatives, a key is said to be dichotomous, and this is the type used here. Let us suppose that you have the photograph illustrated below, in reflected and transmitted light, in front of you. Turn to the next page and read the two alternatives offered at No.1. You will see at once that the photograph is not face mounted, and you are directed to No. 3. The photograph is not color, so you are directed to No. 6. At No.6 it is evident that the glass support is not clear, and this brings you to No. 7. The glass is not white, and this is the end of the trail, the photograph illustrated is a ruby ambrotype.

There are variations on all of these processes and this dichotomous key is meant to be a guide in the identification of glass supported photographs. Further, there is a short definitions section on page --- that will direct the reader to the area within the Process history section.



1. Is the image face mounted?	Yes	2.
	No	3.
2. Is the glass convex?	Yes	Crystoleum
	No	Ivorytype
3. Is the image in color?	Yes	4.
	No	6.
4. Under magnification, can coloured dots be seen?	Yes	Autochrome
	No	5.
5. Under magnification, can lines of color be seen?	Yes	Joly plate
	No	Lippman plate
6. Is the glass clear?	Yes	10.
	No	7.
7. Is the glass white?	Yes	8.
	No	Ruby ambrotype
8. Is the surface glossy?	Yes	9.
	No	Opaltype
9. Under magnification, can dots be seen?	Yes	Computer print
	No	Vitrified
10. Does the glass have a backing?	Yes	11.
	No	17.
11. Is the backing gold colored?	Yes	Orotone
	No	12.
12. Is the backing black?	Yes	13.
	No	Relievo ambrotype
13. Is the image plate mounted to glass overall?	Yes	Cutting ambrotype
	No	14.
14. Is the image area oval with clear borders?	Yes	Sphereotype
	No	15.
15. Does the image plate have a cover glass?	Yes	16.

	No.	Single glass ambrotype
16. Does the image plate have a glass backing?	Yes	Triple glass ambrotype
	No	Double glass ambrotype
17. Does the emulsion swell with a water drop test?	Yes	Gelatin emulsion
	No	18.
18. Is the binder uneven around the edges of the plate?	Yes	Collodion wet plate
	No	19.
19. Does the image have relief?	Yes	Carbon or Woodbury
	No	20.
20. Is the binder reddish or green and negative?	Yes	Albumen negative
	No	21.
21. Is the binder reddish or green and positive?	Yes	Hyalotype
	No	22.
22. Does the plate have a binder?	No	Amphitype

Ambrotype – a collodion positive on glass. May be housed in a case with black backing varnish or other material behind the plate.

Amphitype (Herschel) – A binderless precipitated silver on glass process. Extremely rare.

Autochrome – an additive color screen process formed with a random array of red, blue and green dyed potato starch particles.

Carbon – A pigment process by which pigment in dichromated gelatin is exposed to light through a negative. The areas that are exposed to light harden and the rest is washed away, leaving a photograph that has relief: areas of darker, thicker pigment and highlights that consist of an exposed primary support.

Chromo-crystal – An oval collodion positive, face mounted to a piece of ruby glass. These photographs do not measure above 1.5 inches in diameter.

Collodion wet plate - Several binder tones are possible, such as milky black, brown, gray, or yellowish, depending upon the developing process. Hand-coated plates will have irregular edges, thumbprints and other irregularities. See page --- in process history for clarification.

Crystoleum – a hand-tinted albumen or salted print, face mounted to *convex* glass.

Cutting ambrotype – a collodion positive, face-mounted to another sheet of glass with Canada Balsam.

Gelatin on glass - The edges of gelatin plates will usually be even, when compared with collodion plates. Typically, these plates will have a neutral image hue and will often have silver mirroring.

Hyalotype (Langenheim) – albumen positive on glass, used as a lantern slide or stereo plate. Will typically be backed with ground glass to diffuse the light as it passes through the plate.

Ivorytype – a hand-tinted albumen or salted print, face mounted to flat glass.

Joly plate – an additive color screen process with a grid work of red, blue and green lines.

Lippman plate – a gelatin silver color plate process, very rare.

Opaltype – a collodion, carbon or gelatin positive image on milk glass.

Orotone – a gelatin positive, backed with gold suspended in banana oil.

Relievo ambrotype – a collodion positive with a white or clear background. Sometimes the plate will be backed with a scene or colored paper.

Ruby-glass ambrotype – a collodion positive on colored glass.

Sphereotype – A variation of the ambrotype process where the plate is exposed through a tube so that there is no exposure around the perimeter of the sitter in an oval shape.

Vitrified photo on glass – this process will usually have slight relief between d-max and d-min areas. Surface will usually be glossy overall.

Woodburytype – Very similar in appearance to a carbon print. Woodburytype is a pigment process whereby pigment is deposited on glass with a metal press. The resulting print has relief, like a Carbon print.

ⁱ Eggunike 11

ⁱⁱ *The British Journal of Photography* 1864, p.491.

ⁱⁱⁱ (<http://www.nicephore-niepce.com/pagus/invus5.html>)

^{iv} *The Photographic News*, June 21, 1872, 293

^v *Philosophical Transactions of the Royal Society*, 1840: 12; and Herschel, A.S. "On some original glass photographs produced and preserved by the late Sir John Herschel, Bart., from his earliest Experiments on the Chemical Properties of Light." *The Photographic Journal*, June 15, 1872: 153.

^{vi} Herschel's experimental notes, 1839.

^{vii} Herschel, A.S.: 154

^{viii} Letter, Talbot to Herschel, 29 March 1843.

^{ix} See also Robert Hunt's *Manual of Photography*

^x Eder 340.

^{xi} Mark Osterman, correspondence

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- xii *Anthony's Photographic Bulletin*, Vol.19, 1888:558; *Photographic Arts Journal*, Vol. 6, 1853:148
 - xiii *Photographic Art Journal* Vol.16, 1853: 148-149
 - xiv Werge, *The Evolution of Photography*: 52-53.
 - xv *Anthony's Photographic Bulletin* Vol. 16, 1885: 247-249
 - xvi Mark Osterman, communication
 - xvii Eder 339.
 - xviii http://www.daguerreotype.com/1_table.htm#Langenheim,%20Frederick
 - xix Spindler 1-15.
 - xx Browne 222
 - xxi *Ibid.* 1-15.
 - xxii Gernsheim 195
 - xxiii Patents for Inventions 55-56
 - xxiv *Ibid.* 113-114
 - xxv *Ibid.* 88
 - xxvi Jones 90
 - xxvii Patents for inventions v.1, 88-89
 - xxviii Wilson 100
 - xxix Patents for Inventions 97, 148. There were many patents taken out by Woodbury in the intervening years, improving upon the Woodburytype process: No.105, 1866, No.1315, 1866, No.1918, 1866, No.346, 1870, No. 2171, 1870, No. 3654, 1872 and No.1954, 1873
 - xxx Patents for inventions v.2, 21-22
 - xxxi Cassell's 565
 - xxxii The collotype process was an early printing process. A glass plate was coated with sensitized gelatin and exposed under a negative. Light passed through the negative would harden the gelatin on the glass plate. The unexposed gelatin would then be washed away with water, leaving the hardened, exposed gelatin. The washed glass plate would be coated with ink, adhering to the exposed gelatin and printed onto fine paper.
 - xxxiii *The British Journal of Photography* (26 Feb. 1875), 103
 - xxxiv *Photographic Journal*, 7 (15 Feb., 1861), 99-101
 - xxxv *The Times*, 10th September 1852
 - xxxvi Gernsheim 119
 - xxxvii Patents for Inventions v.1, 34-35
 - xxxviii *Collodion Journal* 5:19, 2
 - xxxix Gernsheim 237
 - xl Bisbee, US patent No. 14,946
 - xli Mettam, R. 1
 - xlii Skaife, *Brighton Herald*, 8
 - xliii Skaife, 1860. 36.
 - xliv Letters to a photographic friend 1860, 241.
 - xlvi Skaife, 1861 advertisement in the *London Times*
 - xlvi Patents for inventions v.1, 82.
 - xlvi Egunnike 13
 - xlvi *The British Journal of Photography*, 1864
 - xlvi Egunnike, 1
 - ¹ Patents for Inventions, Vol. 1, 108-109.
 - li *The Liverpool and Manchester photographic Journal*, 1857, p.232
 - lii *Ibid.* p.231
 - liii *The Photographic Journal*, 15 March 1862, 101
 - liv Patents for Inventions v.1, 2
 - lv *The British Journal of Photography*, March 15, 1862, 102

^{lvi} *Journal of the Photographic Society* 1859, 153

^{lvii} Ellis 34.

^{lviii} Woodbury 331

^{lix} Monckhoven 478

^{lx} Eder 373

^{lxi} Patents for Inventions, v.1, 67.

^{lxii} Towler 245.

^{lxiii} Eder

^{lxiv} In 1901 Maddox received the Royal Photographic Society's Progress Medal for inventions that led to the foundation of the dry plate and film industry.

^{lxv} http://en.wikipedia.org/wiki/Edward_S._Curtis

^{lxvi} Davis, 68

^{lxvii} A term coined by Mark Osterman.

PART 2: THE DETERIORATION AND CONSERVATION OF GLASS SUPPORTED PHOTOGRAPHS

Glass Deterioration

Glass deterioration can be divided into two categories: chemical and physical. Chemical deterioration will manifest because of adverse environmental conditions. Physical deterioration is usually the result of improper handling and housing:

Chemical Deterioration

“Sick glass” has always been a problem for conservators. There are several contributing factors affecting decay, the major ones being those of glass composition, poor founding practice and environment. Others are exposure to aggressive solutions, time and temperature. The usual symptoms are weeping and the formation of crystals. Weeping is often caused by the excess of alkali and the lack of sufficient lime and/or other stabilizing material in the batch. In general, glass with a high proportion of silica to modifiers will tend to be stable whereas if the proportion of modifiers is high then the glass will be much more readily attacked. UV light is known to increase surface corrosion and the presence of sulfur in the atmosphere is known to increase weathering problems.

The chemical nature of decay is varied and very complex. Some of it, such as the weeping and crizzling caused by an excess of alkali and a lack of stabilizers in the glass, is fairly simple but the results of attack by water can be much more complicated. Water is a primary agent of the environment that causes the deterioration of glass. The surface of a glass tends to react with water or even with a humid atmosphere and starts a continuing process in which the effect progresses further into the glass.

Poor storage in the very damp conditions that often prevail in cellars or attics can be a considerable contributory factor to this form of decay. There can be no doubt that poorly formulated glass, which has not been well stabilized or has been made with high alkali content in order to achieve low founding temperatures makes the surface vulnerable to attack.ⁱ



Figure 1



Figure 2

Figure 1 is an example of a poorly housed gelatin glass plate negative and the resulting glass decay that resulted (case study 7). The plate has been broken at some point and stabilized by applying tape to the upper left and bottom central edges, on the emulsion side, and sandwiching the plate between two sheets of modern glass. As the tape aged, the adhesive cross-linked and lost its tack, resulting in the loss of four shards in the top left corner of the plate (only two shards are still present). Black masking and electrical tape were then used in the center of each edge to hold the package together. This allowed the ingress of moisture as the environmental conditions fluctuated, resulting in the formation of droplets of alkali material that crystallized (Figure 2). When the sandwich was taken apart, it was discovered that the decay was present only on the sandwiching pieces of glass and not the glass plate negative. This would suggest that the sandwiching glass was of inferior quality and therefore more prone to decay than the negative plate, which was made of superior glass. More information on this treatment can be seen in *Case Study #7*.

Broken glass

An impact break is one that is caused by a crushing blow to the material (Figure 3). Glass is characterized as a brittle material and therefore, subject to brittle fractures with rapid crack propagation without significant plastic deformation. This variety of fracture may have a bright, granular appearance. They are characterized by an impact cone, where the most damage has been done, surrounded by radiating arcs. Glass is considered an amorphous solid, meaning that it lacks a crystalline structure and a

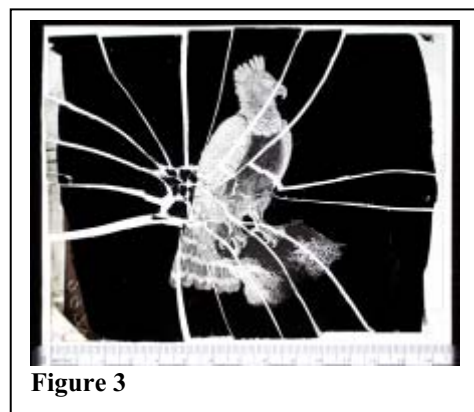


Figure 3

fracture will not follow any natural planes of separation, consequently, glass can break in a *conchoidal* fracture: Cracks will run perpendicular to an applied stress: that is, the shard of a broken sheet of glass will have smooth fracture surfaces.

Blind cracks - Or are there breaks that do not carry through the whole shard. These have to be stabilized primarily to avoid further damage to the support.

Knowledge of stress states and how they affect glass is needed. Sheer stress that is parallel to a face of the material, normal stress that is perpendicular to the face of the material, tensile stress induced by pulling forces, or even compressive stress that can rupture the material are all potentially very harmful to glass with blind cracks and breaks that have not broken the image binder. If the break has not torn or damaged the image binder, these shards will need special attention and stabilization to prevent further damage. (Figure 4)

Transgrainular fractures are fractures that travel through the plain of the material, following the path of least resistance (Figure 5). These fractures are the cleanest and easiest to mend.

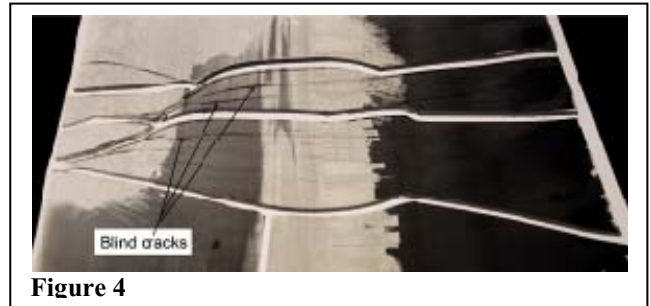


Figure 4



Figure 5

Case Studies

The following case studies are based on what I have encountered under the scope of my time at the George Eastman House conservation lab. The treatment of the interpositive of Abraham Lincoln allowed for many innovations regarding the repair of photographs on glass and that is the treatment on which the rest of the case studies are based. The following table is a guide to the case studies, with the objects listed along the top and the treatments in alphabetical order down the left column.

	1. Lincoln Interpositive	2. negative	3. negative	4. negative	5. ambrotype	6. ambrotype	7. ambrotype	8. negative	9. opaltype	10. stereo-transparency	11. lantern slide
Binder consolidation with B-72									X		
Binder consolidation with gelatin		X									
Black varnish compensation							X				
Blind crack stabilization	X	X									
Cleaning	X				X				X	X	
Cover glass replacement					X	X					X
Glass deterioration								X			
Glass loss compensation	X										
Glass sandwich housing		X	X								
In-painting			X		X	X					
Mending glass with B-72	X	X	X					X		X	
Mending glass with Epoxy				X	X	X					
Secondary support of mat board				X						X	
Secondary support of Silicone	X	X									
Silpat inclined assembly	X		X								
Tape removal				X				X			
Rehousing					X	X				X	
Vertical assembly	X	X	X	X	X	X		X			

Conservation of an American Icon: The Abraham Lincoln interpositive after Alexander Hesler, by George B. Ayres

Case Study #1: 8 x 10" broken gelatin interpositive with mirroring and losses.

Artist: George B. Ayres, after Alexander Hesler
Title/subject: Abraham Lincoln (O-26)
Owner: anonymous
Dimensions: 8 x 10"
Medium/Process: Gelatin glass plate interpositive
Object Date: Ca.1895
Housing: none
CNS No.: CNS 0511:54:01
Conservator: Katharine Whitman

TREATMENT SYNOPSIS

The adhesive residue was removed with acetone swabs and the glass side cleaned with Ethanol/ water (30:70) swabs. The blind cracks were stabilized with warm 25% B-72 in Toluene. The losses were filled with epoxy.

Before



After

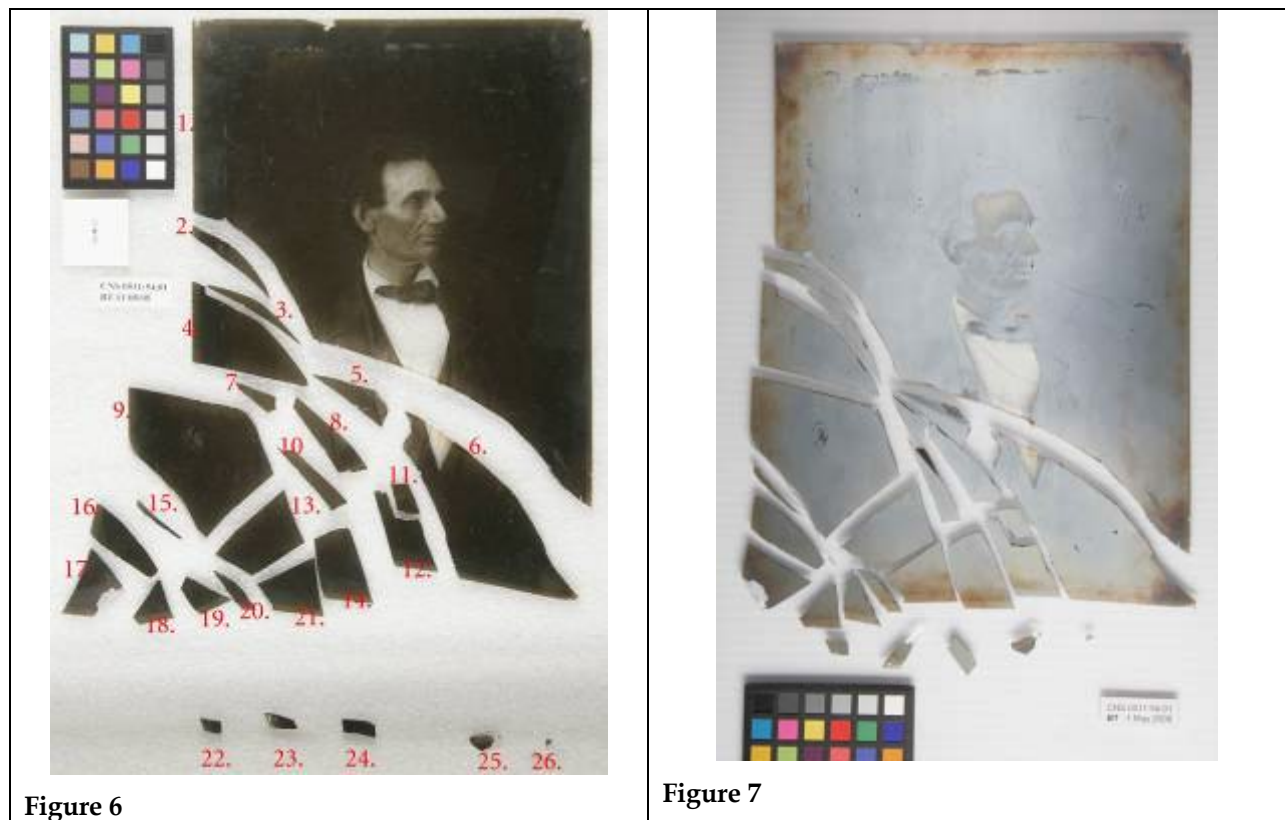
DESCRIPTION

An interpositive of Abraham Lincoln, made by George B. Ayres circa 1895, from a Collodion negative originally taken in 1860 by Alexander Hesler. The piece is broken into 26 pieces with 4 areas of loss. There is an even patina of mirroring on the emulsion side.

CONDITION

Previous Treatment: There is adhesive and paper tape residue along the main piece (#1) and pieces 5 and 6, indicating that this plate was probably broken at two times in the past: once horizontally along the center and repaired with the paper tape and adhesive, and then again when the repair failed, shattering the lower half of the plate.

Glass Support: The plate been broken into more than 25 pieces, with 26 pieces present (Figure 6): piece 1 has been broken from the LCE to the BRC and has cracked in the TRC and along the LE, 9 cm from the top, and on the RE, 23.5 cm from the top. #5 has broken into 2 pieces without breaking the emulsion (WBE), #4 into ~9 pieces WBE, #6 into 6 WBE, #7 has many internal fractures, #8 into ~10 WBE, #10 into 2 WBE, #11 into ~7 WBE, #12 into 2 WBE, #14 into 2 WBE, #16 into ~10 WBE, #19 into ~5 WBE, and #24 into 2 WBE.



There are tiny shards that have been lost along all the break edges. #17 has been crushed in one area with splintering and losses. There is minor soiling overall with fingerprints. There is yellowed and very dry adhesive residue along the break edges of pieces 1, 5 and 6. There are some minor scratches overall.

Binder: There is some delamination associated with the breaks. There are some minor losses associated with the breaks and in the four original corners of the plate from normal use. There is minor soiling and fingerprints on all of the pieces. There is some yellowed adhesive residue in the BRC of piece #1. There are some minor scratches over all. There is some slight yellowing associated with the age of the plate.

Final Image Material: There is mirroring overall with a greater concentration in along the four original edges and in the corners (Figure 7).

TREATMENT

1. The adhesive and paper residues were removed from the glass side and shard interfaces of pieces 1, 5 and 6 with acetone swabs. There was some residue on the gelatin side of the pieces and this was removed with acetone swabs in a light rolling and dabbing motion to discourage the delamination of and image gelatin. The adhesive did migrate under the gelatin in a few areas on shard 1, and was soaked out as well as possible with acetone swabs.
2. The shards with blind cracks were stabilized by wicking in warmed B-72 in toluene with a small brush. Excess adhesive was cleaned up with a dry cotton swab and the pieces were left to cure under weight for three days. After that time, the pieces were stabilized for the remainder of the curing time with sticky wax.
3. The plate was assembled vertically and stabilized with sticky wax. The shard interfaces were cleaned with acetone swabs before the assembly was performed. Towards the end of the assembly, the pieces were too small for vertical assembly. The object was laid flat on a Silpat mat, the pieces fit into place, and Apollo Cyanoacrylate dots were applied to hold the pieces in place.
4. The assembled plate was then brought back to a vertical position and 25% B-72 in Toluene was wicked into the shard interfaces. The plate was then left in position to cure overnight. After that time, the plate was laid flat in a padded box and left to cure for two weeks.

OBSERVATIONS

Because of the iconic stature of this object, extensive research was conducted into the best treatment possible. Many adhesives were considered and tested and innovative applications were explored.

CLEANING:

On an already repaired piece of glass, the adhesive can be determined by the colour and condition of the residue (see Table 1), the date of the repair, the properties the adhesive exhibits, or any available record can provide clues, specifically, trade names such as:

- Cellulose nitrates: Duco cement, Universal (Randolph's) cement, HMG, UHU Hart, Durofix, Ambroid
- Polyvinyl acetate: UHU, Elmer's, White glues
- Acrylics: B-72, B-48n, White glues

Table 1ⁱⁱ

	Clear	Clear yellow	Yellow	Brown	white
--	-------	--------------	--------	-------	-------

Acrylics	X				
PVA	X				
Gelatin	X				
Epoxy		X			
Cyanoacrylate		X			
Silicone rubber		X			
Polyester resin		X			
Waxes		X			
Cellulose nitrate			X	X	
Polyvinyl butyral				X	
Polyvinyl acetate				X	
Casein				X	
Shellac					X
Animal glue					X
Gutta percha					X

How removable the adhesive residue is depends upon its properties. Gelatin binders tend to be more forgiving than collodion binders. Table 2 lists common adhesives, what they are soluble in, and their removability.

Table 2

<u>Adhesive</u>	<u>solute</u>	<u>Removability</u>
Animal glue	water	very
PVA	water	Swells: scrape off
Casein	water	Swells: scrape off
PVA	ethanol	not for collodion
Shellac	ethanol	not for collodion
Alvar	ethanol	not for collodion
Butvar	ethanol	not for collodion
CN	acetone	not for collodion
Acrylics	acetone	not for collodion
Polyester	acetone	not for collodion, more of a mechanical removal
Cyanoacrylates	acetone	not for collodion, mechanical
Urea-formaldehyde	acetone	not for collodion
Epoxy	CH ₂ Cl ₂	debatable
Waxes	naptha	Very
Rubber cement	cellosolve	very

ASSEMBLY:

The Silpat™ fracture interface mending:

The Silpat method involves the mending of the plate at the fracture interfaces and the B-72 film backing method would stabilize the plate from the glass side.

The most common method of repairing broken glass plate negatives currently is to apply an adhesive at the fracture interfaces, therefore returning the object to something close to its original state. When this method is applied to smaller size plates (i.e. 4" x 5"), it can be a very stable repair. Further, adhesives exist that match the refractive index of the glass, making the repair site virtually invisible.

The currently accepted procedure is to apply Epoxy to the fracture interface, then place the fragments in contact, glass side down, upon a sheet of Mylar, shoring the sides of the plate with mat-board, laying a second sheet of Mylar on the emulsion side, and applying weight to the entire sandwich. Even when a minimal amount of adhesive is applied to the fractures sites, there is overflow. The adhesive is pulled out of the repair site by capillary action, onto the glass side of the plate where it is in contact with the Mylar. This can be easily removed with a razor blade. However, there also tends to be some overflow onto the emulsion side of the negative, where it was also in contact with Mylar during drying. When "clean-up" is done within 24 hours of the treatment, before the Epoxy can cure, this adhesive is easily removed with acetone.

While this method insures that the entire plate is properly aligned during treatment, it proves difficult when the object has been broken into many pieces, particularly when there are very small shards. Treatments have been also been performed where the pieces are fully aligned upon a flat surface, and then the adhesive is wicked into the fracture interfaces and is carried throughout the fracture by capillary action. This utilizes a minimal amount of adhesive. However, there is still a tendency for capillary action to pull the adhesive onto the bottom surface of the plate as well, the side against the Mylar. A solution that we proposed to solve this problem was to employ a Silpat™ baking mat as a support.



A Silpat™ mat is made of silicone and fiberglass and has an evenly textured surface. This textured surface provides enough air pockets to prevent the capillary action that can occur on the bottom side of the plate during treatment.

A stage was made on with a sheet of glass, over fiber-optic lights. The Silpat™ mat was then placed on top of the glass and a broken sample plate was assembled upon the mat, emulsion side down since there was no capillary action to carry the adhesive onto the bottom surface. The adhesive was then fed into the fracture with a brush and the capillary action was monitored. The picture to the right shows this procedure and the reduced appearance of the fracture where the adhesive (in this case 25% B-72 in

Toluene) has been applied. When enough adhesive has been applied, a weight was placed on the top surface and it is allowed to dry.

This method of repair produced very satisfactory results, with no trauma to the emulsion side of the plate, or excessive adhesive use. However, the possible adhesives for this method were B-72 in a solvent and Epoxy, because they both match the refractive index of the glass. B-72 was not appropriate, because of the “snowflake” problem described above and because B-72 “travels”: if there were any weak areas between the gelatine emulsion and the glass, the adhesive would be carried into that pocket, impossible to remove. Epoxy was not appropriate due to the afore-mentioned yellowing and irreversibility. The top priorities in determining the best treatment for the Hesler plates is to use the best materials available and to insure there reversibility, making this repair method inappropriate.

Backing with B-72 film:

At the ICROM conference in Amsterdam in 2004, Sara Innocenti of the Accademia di Belle Arti di Brera in Milan, Italy, suggested a treatment for broken glass plate negatives that involved using a pressure sensitive tape to stabilize a broken plate from the glass side. This method stabilizes the plate and prevents the shards from grinding together without introducing adhesive into the interfaces. In light of the fact that research has not been conducted in conservation to find an adhesive that both matches the refractive index of the glass, creating an invisible repair at a fracture interface, and is totally reversible, this backing method is a feasible treatment.

To date, experiments have been conducted on sample negative in the lab to determine the best method for executing the following method. Of the methods tried, applying the B-72 solution to the Mylar in a method similar to how collodion plates are coated has yielded the most even coatings. Flock spraying the B-72 will be investigated as well. This would yield a very even coating that would even out as it is heated in the final repair.

The main problem that has to be considered is that the glass plate originals are not on perfectly flat glass, as is very common with early gelatine dry plates. This means that we will not be able to simply assemble the object on a flat surface and be sure that all of the pieces are perfectly aligned. What is working in our favor is that fact that broken glass can only be reassembled in one way: you will know immediately if there is a mis-match in the assembly. Therefore, the utilization of a surface that will mould to the contour of the plate’s topography would be optimal.

Early experiments on sample, non-smooth flat glass were made by positioning the shards together and laying the B-72 coated Mylar on the top side. A tacking iron was then used to activate the adhesive; this yielded a tight bond to the glass with no migration into the shard fractures. There was a concern that the activated B-72 would migrate up the fracture via capillary



B-72 film, tacking

action and on to the gelatine side of the plate. If the adhesive were to travel onto or under the gelatin it would be virtually impossible to remove. While the tacking iron method yielded a tight bond with no air bubbles, the Mylar was marred and it was difficult to control the temperature of the iron, even on its lowest setting. It would be optimal to use the lowest and most even temperature to activate the adhesive to reduce the strain on the gelatine. More importantly, all heating should be kept even so minimize internal stresses within the glass support. Uneven heating could lead to tiny internal fractures that will weaken the glass and make it much more prone to future breakage. It has been determined that a slow, even heating and cooling of the glass is essential in this treatment.

Next, a sample negative was broken and assembled on B-72 coated Mylar on a "Lab-line" slide warmer. A "Taylor" probe thermometer was used to monitor the temperature of the platen. The temperature was slowly raised over a half hour to 40°C and maintained for 15 minutes. The platen was then turned off and the plate was left on the platen to slowly cool. Upon examination it was determined that this method yielded rather large air bubbles (left pic) between the Mylar and the glass. Another plate was repaired using this method, and while the adhesive was still at 40°C it was flipped over and the air bubbles were worked out with a Teflon folder and my fingertips. This yielded a repair with very few air bubbles (right pic), but would not be practical for a larger negative with many fractures.



B-72 film repair, heat alone



B-72 film repair, heat and pressure

The obvious solution is to remove all of the air from the repair environment before the platen is heated and the B-72 is activated. It has been decided that an aluminum suction table will need to be fabricated that will remove all of the air from the B-72 glass interface. The bottom of the suction table will be coated with aluminum powder to compensate for the non-planar qualities of the glass support, allowing for even contact with the heated surface. Then the platen can be raised to 40°C to activate the B-72.

This method of assembly was abandoned for three reasons. The heating of the glass support could lead to desiccation of the binder and flaking. While the pieces are

stable, the cracks are still very visible: no adhesive is applied to the shard interfaces and therefore the refractive index is not matched to the glass. When an adhesive with the same refractive index is applied, the cracks appearance will be reduced (see case study 1). Finally, the pressure required to remove the air bubbles from between the glass and the Mylar could be detrimental to the emulsion, causing flaking and cracking. It is possible that a vacuum could be set up to remove the air bubbles, and this should be explored at a later date.

Vertical Assembly

Upon consulting Stephen Koob, head of conservation at the Corning Museum of Glass, it has been determined that it would not be possible to assemble the Lincoln interpositive horizontally, and assure that all of the pieces are in perfect alignment. Glass for gelatine photographic processes around 1900 (the date of this object) was produced by the “cylindrical glass blowing” method. Therefore, the Lincoln interpositive is on non-planar flat glass: it has subtle ripples on its surface. The accepted method of assembling non-planar glass in glass conservation is to assemble the object vertically and to use gravity’s pull to fit the pieces together; broken glass can only fit back together correctly in one way, and with experience, a conservator will know when the pieces have come together appropriately.

Vertical assembly: Cracks will run perpendicular to an applied stress: that is, the shard of a broken sheet of glass will have smooth fracture surfaces, and therefore, two adjacent shards of glass will fit back together perfectly and in only one proper way. With experience, a conservator can learn when this position is attained. There are methods of assembly and tools available that will aid in the reconstruction of broken glass supported photographs. The improvements to this method that have been made are innovative in the field of photograph conservation and promises to solve many problems that currently plague conservators of photographs on glass.

The basic, traditional procedure for assembling glass is as follows: A stable shard of glass is supported perpendicularly to the working surface so that there will be no movement during assembly. The object is then assembled, using pressure sensitive plastic tape to hold the shards together. The shards are aligned by visual inspection and feel. It is important that the object is assembled completely before any adhesive is applied to insure precise alignment of all shards. In the case of an object such as the Lincoln interpositive that has broken into 26 pieces, the smallest misalignment will be magnified in the assembly of the subsequent pieces that will lead to a major misalignment by the end of the process. When adhesive is not applied until the last step, these misalignments can be recognized and corrected. Once the object has been assembled completely, adhesive is wicked into the shard interfaces and allowed to cure. The object is then removed from the vertical support, the tape is removed and excess adhesive is cleaned up.

One improvement that has been made to this working method is to use a fibre-optic array of lights in a “light line” to aid in the alignment of the shards: if they are

misaligned in any direction, it is instantly known because the light line will not be straight. A second improvement is to use Vigor sticky wax to hold the shards during assembly. Plastic tape, while easy to use and completely removable, has a flexible plastic carrier that gives minimal support. Vigor sticky wax becomes soft with low heat and hardens at room temperature, providing a stiff support for the assembled pieces. It is also very easily removable once the adhesive has been applied. Additionally, the use of fibre-optic lighting on the edge of the glass illuminates the shard interfaces during assembly and allows the conservator to know when the proper amount of adhesive has been applied.

This method of assembly will also insure that the gelatine side of the plate is disturbed as little as possible. As seen in the initial examination report, there is a even silver patina, on the surface of the gelatine that is very easily marred. The vertical assembly method will insure that as little as possible will encounter this surface.

Adhesives:

In consultation with Stephen Koob, the adhesives appropriate for the repair of clear glass at the fracture interfaces must match the refractive index of the artifacts glass to achieve an invisible repair. Therefore, the adhesive we tested were Paraloid B-72 and Epoxy. Non-refractive index matching or -transparent adhesives, such as Beva, were also considered.

Vinyl resins such as PVAC and PVB have been discussed. PVAC was ruled out as an adhesive because it has a low Tg (28°C) and is prone to cold flow. PVB has a refractive index of 1.49 but it cross-links on prolonged exposure to light (rendering it non-reversible) and should therefore be considered insoluble in the long term. UV setting adhesives were ruled out because they are very unstable over time, resulting in discoloration and cracking: there are too many accelerators in the mix.

Beva is a heat seal adhesive which is widely used for the lining of oil paintings, heat seal facings and the making of laminates with fiberglass. Since BEVA 371 is completely dry at room temperature, it is easy to reassemble fragments and secure them in the right position with a tacking iron. BEVA 371 was specially formulated to have an activation temperature of 65-70°. It is available in a film, which would solve our coating problems, but was deemed inappropriate for this repair because it is slightly opaque and the high temperature required for activation.

Epoxy resins used in conservation are typically composed of two parts, a di-epoxy component and a polyamine cross-linking agent, both of which are combined with diluents and catalysts and have a refractive index of approximately 1.55. This adhesive is very strong and has low shrinkage upon curing. The disadvantage is that this adhesive tends to yellow with time and exposure to light and is virtually irreversible.

Paraloid B-72 is an acrylic copolymer, made of ethyl methacrylate and methyl acrylate, with a refractive index of 1.48. It is soluble in a variety of organic solvents and

has a glass transition point of B-72 is 40°C (approximately 104°F). A solution of 50-70% B-72 in a solvent is recommended for the assembly of glass fragments. A small amount of fumed silica (approximately .01 by weight) should be added to the solution to improve application and drying properties of the adhesive. The B-72 will set hard in 1-2 hours (possibly longer for very thick glass).

Acryloid B-72 – an acrylic copolymer, made of ethyl methacrylate and methyl acrylate. It is soluble in a variety of organic solvents, but is recommended for use in acetone, or mixtures of acetone and ethyl alcohol. (477)

A solution of B-72, 50-70% w/v is recommended for the assembly of glass fragments. A small amount of fumed silica (approximately .01 by weight) should be added to the solution to improve application and drying properties of the adhesive (Koob).

For the purposes of this treatment and the proposed method, Paraloid B-72 has been chosen over Epoxy for its stability and reversibility. The problem with B-72 is that when it is used with a solvent (an aromatic), over time, as the repair cures and the solvent evaporates, “snowflakes” appear in the repair areas (Figure 8), therefore making the adhesive inappropriate for glass plate photograph repair where an invisible, clear repair is desired.



Figure 8

However, it has been proposed that if B-72 were dissolved in the appropriate solvent and coated upon a repair surface and allowed to fully cure, the air bubbles (the “snowflakes”) would not form, because air would not be trapped within the repair site. Then, if the object is assembled, putting these pure B-72 sites into contact, and stabilized, the object could then be placed in an environment where the temperature is slowly raised to 40°C, the Tg of B-72. The B-72 in the repair sites would then soften and adhere the shards together. Upon cooling, the B-72 will again harden, with no snowflake formation.

Cyanoacrylate the dilute alkali solutions on the glass surface cause deterioration of the polymer; thus cyanoacrylate adhesives are generally unsuitable for glass restoration, except for effecting temporary repairs.

The difficulty in assembling a photograph on glass by this method is in choosing an adhesive. There is not a perfect adhesive available at this time. Ideally, the adhesive would need to have a refractive index that matches the artifact's, would have a working time and be available thin enough to wick into a shard interface while providing strength in the final cure, and most importantly, be completely reversible.

These adhesives are reversible, have a refractive index that match plate glass, and have good working properties, but are not used in glass conservation because the alkaline

nature of glass causes the adhesive to “snap bond” upon contact and create a very brittle bond. I have been in contact with a number of adhesive companies and have found a research scientist who is very interested in my problem. He is currently sending me some samples of a special adhesive formulation created for the conservation of paleontological specimens that he believes will not “snap bond” upon contact with glass, leading to a stronger bond.

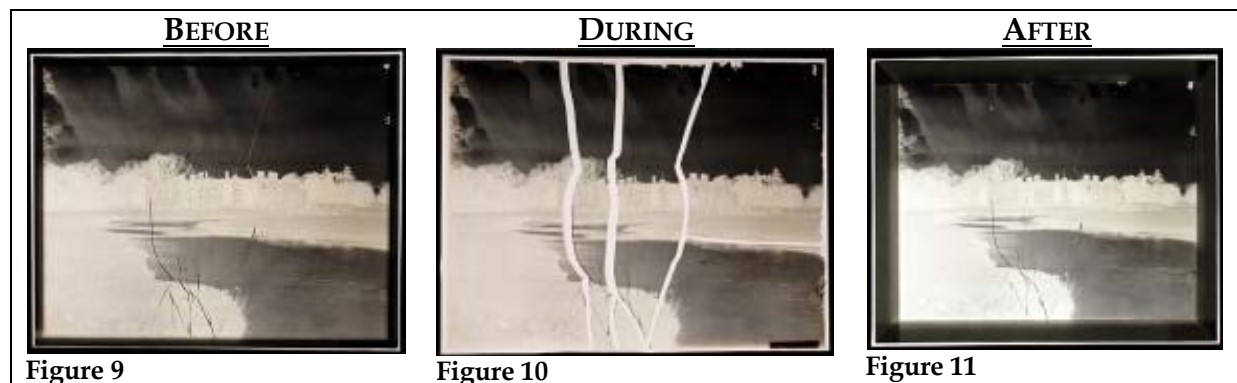
Do NOT use UV adhesives. They are unstable over time. You will see discolouration and cracking. There are too many accelerators in the mix.

Case study #2: Broken 8 x 10" glass plate negative

Artist: WEED BARNES WARD, Catherine
Title/subject: Charlecote from across Avon
Creation Date: Ca. 1891 - 1912
Owner: GEH photograph archives (GEH 1981:2291:02)
Dimensions: 20.5 x 25.5
Medium/Process: Gelatin silver glass plate negative
:
CNS No.: 0704:83:05
Conservator: Katharine Whitman
Other: Accompanying the plate is a piece of brown paper with "Charlecote / from across Avon" handwritten in dark brown ink.

TREATMENT SYNOPSIS

Repair of a broken glass support with 25% B-72 in Toluene and consolidation of the broken gelatin binder with photographic grade gelatin. The plate was then backed with clear silicone and bound into a plate package.

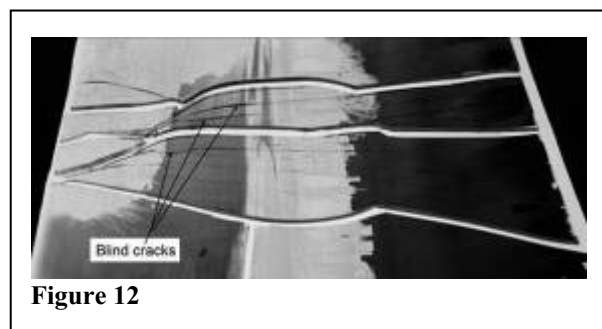


CONDITION

Previous Treatment: The plate shards have been sandwiched between two pieces of glass and bound around the perimeter with P-90 Filmoplast. Within the glass sandwich, a spacer approximately 0.5 cm wide has been placed between the glass and the binder side of the plate. The shards have been placed into the sandwich touching each other.

Glass Support: The plate is broken into six shards with numerous blind cracks in the central pieces (Figure 12). Many of the blind cracks did not run perpendicular to the glass surfaces, making distracting dark lines when viewed with transmitted light.

Binder: There are two small areas of loss in the bottom left corner, and two small



areas in the top right corner and two very small areas in the sky area. There is discolouration in the bottom left corner. Many areas of binder loss were also revealed with the removal of the glass sandwich housing.

Final Image Material: The final image material is in generally good condition with some mirroring visible around the perimeter of the image, in the D-max areas.

Before assembling the plate, the shards were housed in a shallow box, binder side up, on a cushion of Ethafoam. Woven polyester was not be used because the fibers can catch on loose binder or pieces of glass. If there are many small pieces and blind cracks, it may be advisable to assemble the pieces in PhotoShop first (see appendix 3), to minimize handling.

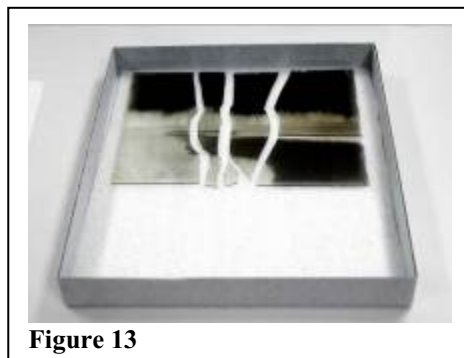


Figure 13

TREATMENT

1. Clean the glass plate and remove housing adhesive residue:
The P-90 residue was removed from the perimeter of the plate with ethanol/water (3:1) swabs. The glass side of the plate was cleaned with ethanol/water (3:1) swabs. The shard interfaces were cleaned with acetone, and inspected with a microscope to ensure that they were clean.
2. Consolidate lifting binder:
Lifting binder was laid down with 2% photographic grade gelatine, applied with a small brush, covered with a piece of silicone-release Mylar®, and pressed with gentle finger pressure. This was then left to set under light weight.
3. Consolidate blind cracks in the glass:
Blind cracks and breaks that had not broken the gelatine were stabilized with warmed, 20% B-72 in toluene, applied with a steel wool swab (see *wicking adhesive*, below), and dried under lightweight.
4. Assemble plate vertically:
The shards were assembled vertically with the aid of a lightline, and held in place with Vigor® sticky wax (see *assembly notes* below). Before each placement, the fracture line of each shard was swabbed with an acetone soaked swab and inspected to ensure that the shard-fracture interface was as clean as possible.
5. Wick in adhesive:
20% B-72 in toluene was wicked into the fracture interfaces using a steel wool swab as an applicator. A fibre optic light was set up to illuminate the fracture interfaces, and to permit observation of the progress of the adhesive. Once the adhesive was

fully applied, the plate was left undisturbed overnight. The assembled plate was then backed with silicone-release Mylar®, a piece of stiff board and laid flat to cure for two weeks.

6. Clean the glass side of the plate:

Once the adhesive was fully cured, the sticky wax was removed with a heated scalpel (Figure 14) and Naphtha swabs. The excess B-72 was removed with B-72 swabs.



Figure 14. Removal of sticky wax with a heated scalpel.

7. Create a secondary support of clear Silicone:

The repaired plate was faced on the emulsion side with a sheet of glass of equal size and sealed around the perimeter with sticky wax (Figure 15), applied with a modified hot glue gun. A barrier of silicone release Mylar® was placed between the two sheets of glass to protect the emulsion.



Figure 15. Application of wax seal.

This package was then placed in a Plexiglas® box that matched the outer dimensions of the glass sandwich. The box was lined with a thin, sintered Teflon® and had a removable bottom made of corrugated board. The removable bottom facilitates removal of the plates once the silicone has set.

Clear P-4 silicone, was then mixed in a 1:10 ratio of catalyst to base, in a disposable clear plastic cup. Enough silicone was mixed to create a backing that was 0.2 – 0.25 of an inch thick (Figure 16. **Silicone backed glass plate.**).

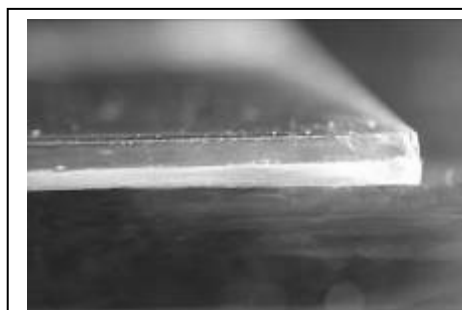


Figure 16. Silicone backed glass plate.

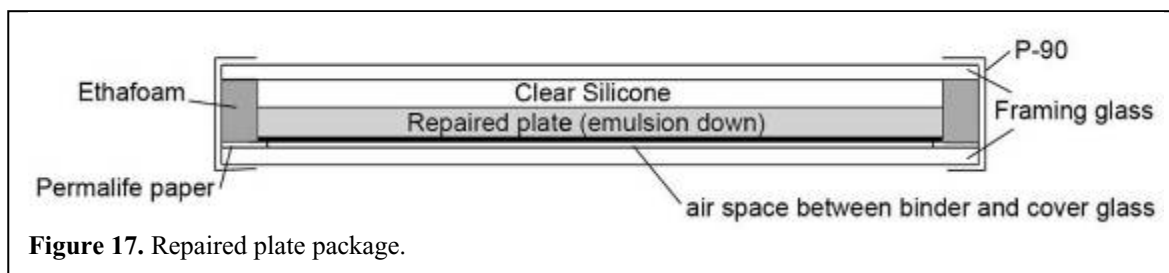
The fully mixed silicone was poured onto the center of the glass side of the plate and allowed to flow into the four corners of the mold. P-4 is a low viscosity Silicone that has a curing time of about four hours. Any air bubbles will rise to the surface and dissipate in that time.

Once cured, the plate was removed from the Plexiglas® by gently manipulating the bottom of the box to release the silicone. The facing glass and silicone-release Mylar® were then separated by removing the wax seal with a scalpel and Naphtha swabs.

8. Create a glass sandwich:

Two sheets of framing glass, both cut 0.5 inch larger than the image plate on each side for a final size of 9 x 11 inches, were placed on either side of the silicone/glass

plate. Spacers, made of four pieces of Permalife® paper, were placed around the perimeter of the emulsion side of the glass plate, and filler material of Ethafoam®, was placed around the perimeter of the silicone/glass plate. The entire package was then bound with P-90 Filmoplast (Figure 17).



OBSERVATIONS

Notes on glass sandwich housings:

Of concern with this housing is the possibility of glass deterioration. Another broken plate, brought into the conservation lab for treatment, had been housed in a glass sandwich. It was found upon disassembly that the deterioration was restricted to the glass sandwich (see case study 7). The glass side of the negative that was touching the housing glass showed moderate glass deterioration. There were crystals throughout the surface. The reason for this phenomenon is a combination of interacting factors: the use of inferior sandwiching glass (i.e. not borosilicate glass) and trapped moisture migrating within the sandwich. When an inferior glass, that is more prone to deterioration, is used, the likelihood of the alkali leaching out of the glass structure in humid conditions is much higher. Placing two pieces of this material into intimate contact compounds the problem.

Further, the shards had also been placed into the sandwich in contact with each other. This made it difficult to remove the shards from the housing without grinding them together. Such action could lead to further damage to the image binder. Broken glass plate transparencies should not be stored with the shards in contact with each other. They are very fragile and easily chipped. In addition, the P-90 Filmoplast tape was stuck to the edges of the glass, risking damage to the binder in that area. A barrier of thin Polyester film (0.001") or microcrystalline wax should be placed on this edge before the P-90 is applied so that this adhesion does not occur.

The completed glass housing created for this project is discussed in detail below.

Notes on vertical assembly:

When dealing with non-planar flat glass, such as that found in most historic glass plates, the only constant force one can rely on is gravity. It is virtually impossible to assemble non-planar glass precisely on a non-vertical surface: the subtle topography of the glass surface, combined with the forces of gravity, prevents their precise alignment.

Breaks in glass are brittle and not plastic; therefore, broken glass can fit together properly in only one way. To assemble glass plates precisely, vertical assembly is recommended by Stephen Koob, head of conservation at the Corning Museum of Glass in Corning, New York. With the proper precautions, this method can be highly successful for the assembly of broken glass plates of up to about 8 x 10 inches in size. For larger plates, that are thick enough to safely assemble

vertically, it is advisable to set up a thick (8 ply) matboard support on the binder side of the plate. This will add stability during the assembly process. With practice, a conservator will get the “feel” for assembling the shards.

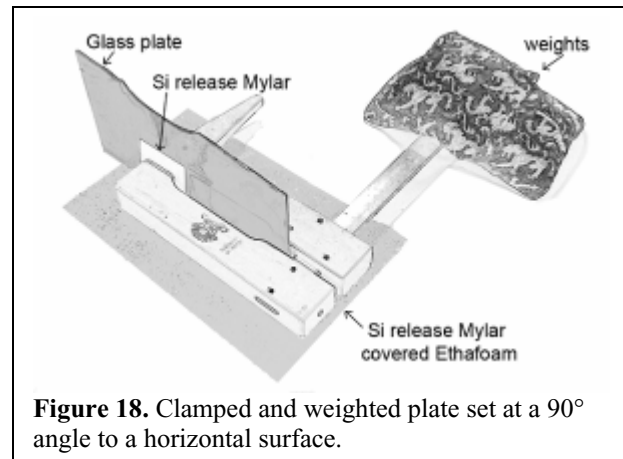


Figure 18. Clamped and weighted plate set at a 90° angle to a horizontal surface.

When reassembling glass plates vertically, a large shard must first be selected as the base piece. This piece must be supported so that it is at a 90° angle to a leveled horizontal surface. During the example treatment, a bubble level was used to insure that the clamp was horizontal, and mat board was used to shore up the far end of the clamp. The wooden section of the clamp rested on a thin piece of Ethafoam®, so that the bottom edge of the plate was protected. The largest piece was then placed in the clamp, binder side *away* from the sitter, with a piece of silicone release Mylar® between the plate and the cork of the clamp. Weights were placed on the far end of the clamp to ensure the plate was stable (Figure 18).

Vertical assembly, with the aid of a “*lightline*” will assure the proper placement of the glass shards. A straight line of light, created by a fibre-optic array, will also aid this process greatly. When the light is directed onto the shard interface, *not* at a 90° angle to the interface, any misalignment will be marked by a crooked line (Figure 19). As the pieces are brought into alignment, the *lightline* will become a straight line (Figure 20). A less expensive alternative to the *lightline* could be a flashlight fitted with a snoot that creates a straight line of light: any straight-edged beam of light will suffice.

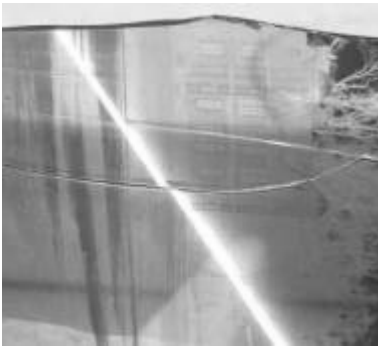


Figure 19. Misaligned shards, note the jagged light line.

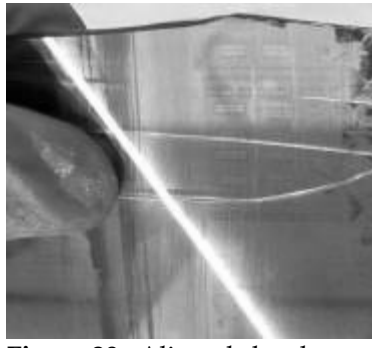


Figure 20. Aligned shards, note the straight light line.



Figure 21. Tacking shard in place with sticky wax.

As the pieces are assembled, sticky wax, such as that used for lost-wax casting in jewelry making, is very useful for holding the shards in place. The wax comes in sticks that can be cut into lengths as needed. Using a pin to hold the wax, warm the wax slightly over an alcohol lamp and place it on the *glass side* of the assembled shards (Figure 21). Enough pieces of wax should be used at sufficient intervals to support the glass as much as possible without impeding the wicking-in of the adhesive later in the treatment: one piece of wax for every four centimeters of shard interface is suggested. When the plate is completely assembled, the lightline should cast a straight line across all of the shard interfaces.

Assembly of the pieces should be performed in a sequence that will *not* call for the placement of a shard that will cause an acute angle to form (Figure 22). The sharp edges of glass fragments will typically prohibit the insertion of an acute-angled fragment into an acute-angled area. If need be, two shards can be positioned at once to avoid this situation. With the correct order of assembly, this eventuality can be prevented.



Figure 22. An example of improper assembly of an acute angled shard.

Notes on wicking in the adhesive:

In this method of assembly, a fine grade steel wool swab (Figure 23) is very useful for the application of adhesive. The swab acts like the nib of a fountain pen, holding the adhesive and feeding it into the shard interface. Capillary action pulls the required amount of adhesive into the interface with minimal excess. An alternative to this tool could be a dosing bottle and tip. These bottles and tips cost about \$17 USD for ten bottles

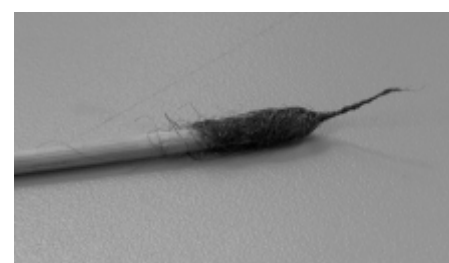


Figure 23. Steel wool swab.

and \$12 USD for ten of the smallest size dosing tips, and are available from Cyberbond Incorporated.

Blind cracks need to be stabilized before assembly because they will be difficult to handle during assembly: the gelatine binder will shrink over time and tend to pull the glass shards apart; as a result, blind cracks may become full breaks. Warmed adhesive should be used, and ideally, the glass should be warm (however, this may desiccate the binder), so that the adhesive will flow further into the cracks. However, the warming of a gelatin plate could have adverse effects on the binder; more research needs to be conducted in this area. There may be a small air bubble trapped at the very tip of the crack, but this will tend to be minimalⁱⁱⁱ.

Figures 13, 14, and 15 illustrate the wicking of the adhesive into the shard interfaces. In this treatment, 20% B-72 in toluene was used. Figure 24 is a close-up shot of the shard interface before wicking, lit with the light line on the edge of the plate to illuminate the interior of the plate and highlight the fractures. The wicking occurs very quickly along the interface. Figure 25 illustrates the wicking-in of the B-72: the area that has received the adhesive is to the left of the swab and has become transparent because the refractive index of the B-72 matches that of the glass plate. A fibre optic light trained on the edge of the glass plate will illuminate the fracture lines, allowing for the observation of the wicking adhesive. Figure 26 shows the shard interface with the adhesive fully applied.



Figure 24. Aligned shards before adhesive application.



Figure 25. During adhesive application.



Figure 26. After adhesive application.

Notes on P-4 clear Silicone and glass sandwich:

As a rule, a glass plate that has been broken into many pieces, or is larger than 5 x 7 inches, will require a secondary support as a part of its housing. P-4 clear silicone, has passed the PAT and is appropriate for use with photographic materials. In this case, the silicone was used as a barrier layer between the glass side of the repaired plate and the backing glass.

Figure 27 illustrates the final plate package. The clear silicone was backed with another sheet of framing glass that measures 0.5 inch larger than the perimeter of the image plate. A filler material of



Figure 27. The final plate package.

Ethafoam® was used to fill the gap around the perimeter. Permalife® paper, cut slightly wider than the Ethafoam® filler, was placed against the emulsion side of the image plate to create an air space between the emulsion and the cover glass. The package was then bound around the perimeter with one piece of 2-inch P-90 Filmoplast tape to create a seal.

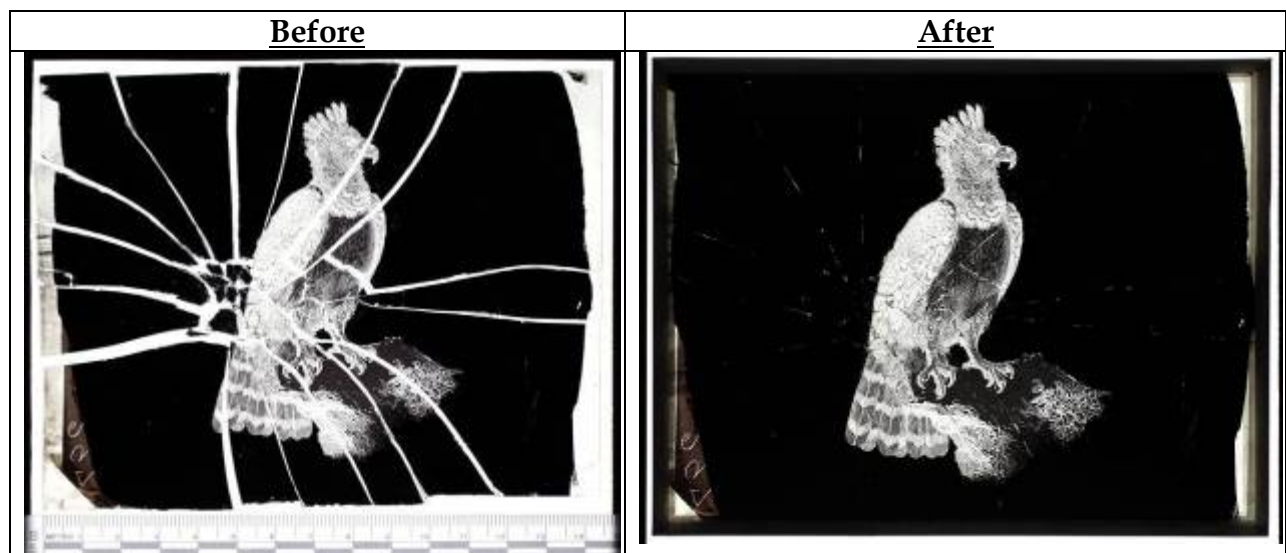
This package creates a stable support for the entire plate that permits viewing of the entire image. For large format photographs on glass that have been broken, this treatment will make the plate accessible to researchers and protect the image from further damage.

Case Study #3: Impact shattered 4 x 5" glass plate negative

Artist: Unknown
Title/subject: Thrasaete - harpie / un expression de férocité terrible á laquelle aioule
Owner: GEH archives
Creation Date: Ca.1920
Dimensions: 10.8 x 14.0 cm
Medium/Process: Gelatine silver glass plate positive
CNS No.: 0611:54:03
Conservator: Katharine Whitman

TREATMENT SYNOPSIS

The shattered plate was assembled on an inclined Silpat® mat and repaired with 25% B-72 in Toluene. The losses in the masking were in-painted with watercolors. The plate was then sandwiched with Borosilicate glass and P-90.



DESCRIPTION

A gelatine developing-out glass plate negative, with black carbon masking on the emulsion side.

CONDITION

The glass support is impact shattered with small losses and minor soiling. The binder is in good condition with some minor losses at the shard interfaces. Silver mirroring is visible on the edges where the emulsion is exposed. The masking is in good condition with some small losses along the shard edges.

TREATMENT

1. The shards were placed into a padded box, in an approximation of the correct arrangement.
2. Assemble the shards and wick in adhesive.

An inclined assembly stage was created with a Silpat lining to impede the migration of the adhesive onto the binder side during treatment. The Silpat a silicone and Teflon non-stick mat used in baking. The microtextured surface prevents capillary action between the stage and the image plate. Pieces of matboard, held in place with tape and bulldog clips, were placed perpendicular to each other as guides for the assembly of the shards.



Figure 28

The shards were assembled on the stage. Precise alignment of the shards was not done until they were all on the stage. The impact shattering nature of the break created many tiny fragments that radiated out from the center of the impact area: shards had to be manipulated during assembly and for ease of assembly the tacking of the pieces was left until just prior to adhesive application. Figure 30 illustrates complete assembly of the shards, with the ceiling light reflected in the surface to show their misalignment.



Figure 29



Figure 30

Once stabilized, 20% B-72 in Toluene was wicked into the shard interfaces with a steel wool swab (Figure 31). After allowing the adhesive to set for 24 hours, the plate was inverted and it was discovered that adhesive had migrated onto the binder side of the plate in the area of the plate where the shards were the smallest. It was very easy for too much adhesive to be applied in this area (Figure 32). The excess adhesive was removed by dabbing the area with acetone cotton swabs, and the adhesive was left to cure for two weeks.



Figure 31



Figure 32

3. In-paint losses in black masking media.

The losses in black masking material on the binder side of the plate were in-painted with Winsor and Newton "lamp black" watercolors.

4. Sandwich plate between sheets of Borosilicate glass.

The plate was sandwiched between two sheets of Borosilicate glass, with Peralife spacers, and bound with Filmoplast P-90.

OBSERVATIONS

The current accepted method of assembling broken glass plate negatives is to apply the adhesive to the shard interface in a series of small drops, then place the shards into contact on an inclined surface. One of the problems with this method of assembling plates is that a lot of excess adhesive is wasted and travels onto the binder side of the plate (caused by capillary action between the Mylar and the plate), requiring clean up with solvents. The use of the Silpat® mitigates some of that problem, unless there are many small shards in the repair (Figure 32).

When it comes to assembling larger pieces, over 4 x 5", it is impossible to align the shards precisely. Historic glass is non-planar: there are slight variations in the surface of the glass. When assembling these pieces against a flat surface gravity will pull the pieces out of proper alignment.

However, the final assembly of the shards was very satisfactory. The negative is in a state where it can be viewed again and scanned into a computer without having to deal with the many shards of glass. In the case of impact shattered pieces such as this one, this treatment is highly recommended.

Case Study #4: Broken 5 x 7" glass plate negative with losses

Artist: LAZARNICK, Nathan
Title/subject: [Crowd gathered near automobiles]
Owner: GEH archives (no number)
Dimensions: 16.5 x 21.6 cm
Medium/Process: Gelatine glass plate negative
Object Date: Ca. 1920
Housing: None
CNS No.: 0607:83:04
Conservator: Katharine Whitman

TREATMENT SYNOPSIS

Removal of pressure sensitive tape from the emulsion side of the plate. The broken glass was repaired with Epotek 301 Epoxy. It was decided not to fill the losses and to create a form filling secondary support of matboard.

Before



After



DESCRIPTION

Gelatine silver glass plate negative on glass 2mm thick.

CONDITION

Previous Treatment: Long, diagonal break stabilized with pressure sensitive tape on the emulsion side.

Image Plate: The binder is lifting in small bubble-like areas, mostly along the edges (see photo-documentation). There are some small losses along the break lines and associated with the glass losses. The emulsion is lifting more severely on the acute angle of a shard located on the lower edge. There is pressure sensitive tape along the main diagonal break. There are minor scratches overall. There are small areas of silver mirroring towards the left and right edges.

TREATMENT

- Tape removed by dissolving adhesive and carrier with acetone.
- Cleaned with ethanol/water swabs.
- Binder consolidated with photo-grade 5% gelatine.
- Repaired broken glass with Epoxy.
- Created a form-fit secondary support of mat-board and a four-flap enclosure.

OBSERVATIONS

When there is tape on the binder side of the plate, it is very important that acetone, or another appropriate solvent, be used to dissolve the adhesive and carrier to prevent damage to the binder. The gelatine along a break will tend to separate from the glass and any mechanical removal of the tape will lift and tear the emulsion as well.

It was decided to not fill the losses because the object is an archives piece with very low demand. Two-part Epoxy was used for the same reasons. Epoxy results in a repair with the same refractive index as glass, so it is clear, but has debatable reversibility issues. Methylene chloride (CH_2Cl_2) will soften Epoxy to a gel that can be scraped off, but is highly toxic and must be used in a fume hood. The advantage of using Epoxy is that it will fully cure in a week with a very strong bond.

It is highly recommended that a form-fitting secondary support of matboard be created for objects with losses. This will ensure that the loss edges will not cause tearing of the enclosure. Further research needs to be done regarding the creation of fills for gelatin glass plate images on glass (see also case study 11).

Case Study #5: Broken ambrotype with image losses

Artist: Unknown
Title/subject: [seated man]
Owner: GEH archives (GEH No: 1970:021:0051)
Dimensions: 8.3 x 7.0 x 0.7 cm
Medium/Process: Tinted ambrotype
Object Date: Ca.1865
Housing: none
CNS No.: 0611:13:03
Conservator: Katharine Whitman

TREATMENT PURPOSE

The broken glass support was repaired with Epoxy. The losses in the collodion were inpainted with watercolors and a new plate package was created.

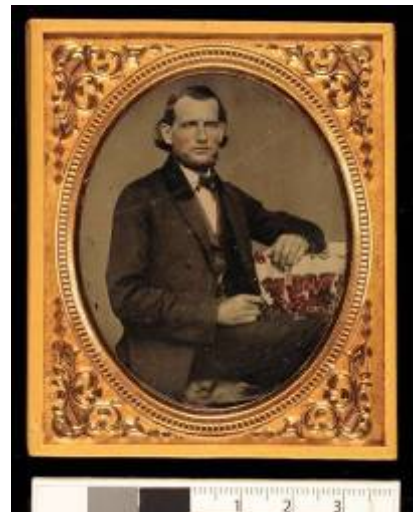
Before



During



After



DESCRIPTION

Sixth plate ambrotype, tinted on the table and the sitter's cheeks, and backed with white mat board that has been painted black. The brass window mat is the only part of the original case still present. There is a white, pressure sensitive archives sticker in the bottom left corner of the cover glass with the GEH accession number. The same number is repeated on the verso of the backing board in the bottom left corner in black ink.

CONDITION

Previous Treatment: The plate has been given a modern cover glass and bound around the perimeter with yellow paper tape.

Housing: Original case is missing. The only part remaining is the brass window mat, that is in very good condition. The original cover glass has been replaced with a modern glass approximately 2mm thick.

Image Plate: The image plate has minor soiling and fingerprints on the image side. The plate has broken into two pieces across the top half of the plate. There are small image losses along the break lines. The black carbon Japanning has severe losses.

TREATMENT

1. Yellow binding tape removed.
2. Both sides of the image plate were cleaned with a soft brush.
3. The broken glass support was assembled vertically and held on Japanning side with wax where the Japanning was lost. Figure 33, to the right, shows the approximate location of the sticky wax during stabilization. In the case of a plate that does not have extensive japanning losses, the wax could be applied on the edge of the glass side of the plate, where the japanning ends, or the thin edges of the plate. Epotec 301 was then wicked into the shard interface with a steel wool swab.
4. After one week of curing, the wax was removed with heated spatula and Naptha. Excess adhesive was removed with an acetone swab.
5. Distracting losses were toned with Winsor and Newton watercolours.
6. The brass mat was cleaned with EtOH/water swabs.
7. The cover glass was replaced with Borosilicate glass and sandwiched with black acrylic velvet backing, the card it arrived with, and bound with P-90 toned with Bronze yellow acrylic paint and Myan Gold mica powder.
8. Four-flap, Tuxedo case housing per directions by Zita Zor (Eastman House intern) was created.



Figure 33

OBSERVATIONS

Notes on cleaning:

Process identification is extremely important before undertaking any treatments: even those as simple as surface cleaning. Collodion binders are very sensitive to solvents. Figure 34 is an example of a collodion negative that has been used to determine its sensitivity to a variety of solvents. The two solvents tested that did not seem to affect the binder were Xylene and Heptane. This information should be taken with a grain of salt: no two collodion negatives will necessarily react to a solvent the

same way. There were a wide variety of varnishes available for collodion negatives and without spot-testing one cannot be sure how the varnish and collodion binder will react. It is best to limit the surface cleaning of a collodion negative to a soft dry brush.



Figure 34

Silver mirroring can be very sensitive to any abrasion or solvent exposure. It must be determined if its preservation is a priority in treatment. Silver mirroring is seen as a natural patina to some, and there is debate over whether its removal is beneficial to the object.

It is usually acceptable to surface clean the glass side of a negative. It is actually advisable to clean the glass side of a negative: glass gets dirty over time. Substances like dust and nicotine from cigarettes settle on the glass and absorb moisture, aiding the formation of alkalis and deterioration. The alkalis in turn absorb dirt and compound the problem.

When undertaking to clean a glass plate negative there are a number of steps that need to be taken to insure that it is done safely:

- Use water or a non-ionic soap 20:1 that is alcohol based so there is no residue. Start surface cleaning with tap water and rinse with deionized water.
- Any labels should always be removed. They will only trap dirt and moisture and promote degradation.
- Use a cotton swab for cleaning – this is better than a brush.

Notes on adhesives

It is not advisable to use Epotec 301 epoxy on a photograph with a collodion binder because of reversibility issues. To reverse an Epoxy repair the plate must have a methylene chloride poultice applied to the fracture for 2-4 hours to soften the adhesive, which can then be removed mechanically. Collodion binders, the varnish layer and the jpanning tend to be very sensitive, and they may be severely damaged by this treatment. B-72 in Toluene is recommended as an alternative.

The toning of the losses with watercolour worked very well. It is very important to keep the toning in the area of the loss, where there is no varnish or collodion, and to keep the brush as dry as possible.

The creation of a new plate package with Borosilicate glass and toned P-90 restored the original aesthetics of the plate.

Case study #6: Broken 1/16th plate ruby ambrotype with losses

Artist: Unknown
Title/subject: [Portrait of a woman]
Owner: GEH archives – GEH1981:2526:001
Dimensions: 4.2 x 3.6 x 0.5 cm
Medium/Process: 1/16th plate Ambrotype on ruby glass
Object Date: Ca. 1860
Housing: None
CNS No.: 0611:13:01
Conservator: Katharine Whitman

TREATMENT SYNOPSIS

The plate was assembled and mended with Epotek 301 epoxy and image losses were inpainted. A custom made housing was created that allows viewing of both sides of the plate.

Before



Figure 35

During



Figure 36

After



Figure 37

DESCRIPTION

A sixteenth plate red ruby glass ambrotype (Figure 38), with tinting on the sitter's cheeks. With cover glass, preserver, and brass window mat present behind the image plate (Figure 39). The case is missing. Archives sticker on the verso of the cover glass: typed "81:2526:1".

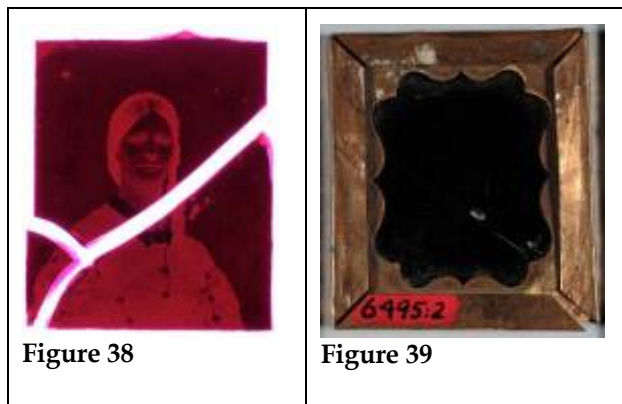


Figure 38

Figure 39

CONDITION (see Figure 35)

Previous Treatment: Preserver and glasses are held together with string.

Housing: The preserver is very tarnished and broken through in the bottom left corner. The cover glass is broken diagonally from the bottom left corner to the central right edge. The rest of the case is missing.

Image Plate: The image plate is broken diagonally, consistent with the cover glass break, and in the bottom left corner. The image binder is flaking with losses along the break lines. The binder is bubbling with losses to the right of the sitter's neck. There are dusty accretions along the bottom edge from the center to the right corner. The varnish is clouded slightly over the sitter's face and in the bottom right corner.

TREATMENT

1. Glass support cleaned on the non-image areas with 20:80 EtOH/Water swabs.
2. Glass support was assembled vertically, stabilized with wax and repaired with Epotek 301.
3. After 1 week of curing, the wax was removed and excess adhesive removed with Naphtha and 20:80 EtOH/water swabs.
4. Losses in the glass in the center of the image were toned with Golden acrylic paints.
5. Brass mat cleaned with EtOH/water swabs.
6. Cover glass was replaced with Borosilicate glass. The original cover glass was repaired and housed with the original object, in a separate four flap enclosure.
7. New case was constructed (see double-view housing directions) and a four-flap enclosure created.



Figure 40



Figure 41

OBSERVATIONS

As stated in the sixth plate ambrotype case study, it is not advisable to use Epotek 301 epoxy because of reversibility issues and the sensitivity of collodion emulsions. The use of acrylic paint was not as satisfactory as the watercolour toning used in the sixth plate case study. The toning was more opaque, but took a long time to

dry and caused some lifting of the collodion binder surrounding the loss area (Figure 37).

The double view housing (see appendix 4) reconstructs the original aesthetics of an ambrotype case. The housing allows the viewer to see both sides of the image plate by reflected and transmitted light. The velvet backing material in this design is more useful for clear glass ambrotypes, but in this case, it serves to pad the glass of the image package.

Case study #7: ½ plate, passé-partout style ambrotype with backing losses

Artist: Unknown
Title/subject: [group of four men]
Owner: Rebecca Norris, Baltimore, MD
Dimensions: Passépartout: 15.3 x 13.1 cm
Medium/Process: ½ plate Ambrotype
Object Date: Ca.1858
Housing: Verre eglomise style passé-partout
CNS No.: CNS 0610:14:08
Conservator: Katharine Whitman

TREATMENT SYNOPSIS

The ambrotype was removed from the frame and opened from the back of the passé-partout. The housing was cleaned and a new backing of acrylic velvet paper was placed behind the image plate.

Before



During



After



CONDITION

Previous Treatment: The original backing of the passé partout (European) has been replaced with a brown paper and the entire package has been placed in a later period, Ogee style (American) frame.

Housing:

Passé-partout: The original binding tape is present and torn at the corners and along the edges. The cover glass is in fair condition with some mild deterioration on the inner surface and soiling on the outer surface. The window mat is in very good condition

Frame: The backing board is warped, stained and held in with two modern nails. The plate housing is shored into the frame with two ball-point pens.

Image Plate: Upon initial examination, the binder and image are in very good condition. The black backing material is flaking with some losses. The image plate was coated with asphalt on the emulsion side.

TREATMENT

- The passé-partout housing was opened from the recto mechanically with a dull scalpel.
- Upon opening the passé-partout it was determined that the housing was in good condition and only cleaning was needed. The glass was cleaned with 50:50 alcohol/distilled water, swabbed on.
- The glass side was cleaned with 50:50 alcohol/distilled water, swabbed on.
- The plate was replaced in the passé-partout and held in place with P-90 Filmoplast tape, and backed with a piece of black acrylic velvet. The paper backing was then replaced, using PVA.
- The paper tape edges of the passé-partout were consolidated with PVA and fills were done with Golden acrylic toned Japanese tissue.
- Additional in-painting was done with Winsor and Newton watercolours.

OBSERVATIONS

This was a rather simple and highly successful treatment. The visual continuity of the image plate was renewed with minimal impact on the original object materials.

Notes on reticulating black varnish

Reticulating varnish has traditionally thought to be the result of poorly formulated varnish. However, there is evidence that some reticulation may be caused by glass deterioration beneath the varnish^{iv}. Varnish can undergo some plastic deformation, causing air pockets between the glass and varnish that appear as distracting lighter areas when the plate is viewed. In other cases, the varnish may crack first, allowing the ingress of moisture and resulting in hydrolytic glass deterioration, compounding the problem.

Various modern varnishes have been recommended for the replacement of reticulating historic varnishes. However, glass deterioration will affect the new varnish with any fluctuations in relative humidity. Stabilization at the proper relative humidity will mitigate additional corrosion.

The introduction of a separate black backing, such as acrylic (non-hygroscopic) black velvet, will restore the aesthetics of the plate without disturbing the historic varnish. Additionally, the introduction of B-72 into the air pockets is another option to stabilize the reticulating varnish. However, this non-reversible treatment can be very delicate and time consuming.

Chemical analysis^v, conducted by Susie Clark in 1998, of black varnish has shown the layers to consist of shellac, soot and lamp black. The research goes on to suggest either the use of modern materials such as a mixture of carbon black and B-72 in acetone or a traditional mixture of shellac in methylated spirits and carbon black for the

in-painting of lost black varnish. While these are viable options, these alternatives obliterate the original backing.

Case study #8: 8 x 10" broken gelatin glass plate negative with deteriorated cover glasses and two small losses.

Artist: George B. Ayres
Title/subject: Abraham Lincoln (O-2)
Owner: anonymous
Dimensions: 8 x 10"
Medium/Process: Gelatin glass plate negative
Object Date: Ca.1895
Housing: none
CNS No.: CNS 0511:83:02
Conservator: Katharine Whitman

TREATMENT SYNOPSIS

The plate was removed from the glass sandwich housing and the double-stick tape removed in an acetone bath. Remaining carrier and adhesive was removed with acetone swabs. The plate was then assembled vertically and mended with 25% B-72 in toluene.

Before



Figure 42

During

After

DESCRIPTION

A monochromatic, gelatine negative on glass ~1.25 mm in thickness. There is retouching in the face and clothing of the subject that is in good condition.

CONDITION

Previous Treatment: The negative has broken and been stabilized with yellowed pressure-sensitive tape in the TRC and along the BE, and then sandwiched between two sheets of glass measuring approximately 25.5 x 20.4 x 0.2 cm. The sandwich has been secured with black paper tape that has been over-taped with black plastic tape in the central area of all four edges. Each piece of tape is approximately 6 cm long. In

addition, the silver mirroring of the image material has been wiped away from the central area of the image.

Glass Support:

The negative has broken diagonally from the TLC to the BCE (please see photodocumentation), and the TL corner has also broken off. There are two small shards from the TL corner: one piece has the letters "B.A." handwritten in black ink along the TE, and the second is slightly smaller. There are minor losses along the broken edges and two areas of complete loss in the TL corner. There is minor soiling and fingerprints over all the pieces. There is adhesive residue present from the pressure sensitive tape that has cross-linked and become brittle (see previous treatment). There are some minor abrasions overall. There is insect frass between the sheets of repair glass in the TL corner (Figure 43). There is glass deterioration occurring where the object glass has been in contact with the repair glass, in the form of small star-like crystals (Figure 44). There are long bubbles in the glass associated with the manufacturing process.



Figure 43



Figure 44

Binder:

There is minor delamination occurring along the break lines. There are losses in the TL corner, associated with the support glass loss, and small losses along the breaks. There is some minor soiling overall. There is adhesive residue present from the pressure sensitive tape that has cross-linked and become brittle (see previous treatment). There are minor abrasions in the central area of the emulsion where the silver mirroring has been wiped away. There is minor yellowing associated with natural aging.

Final Image Material:

There is strong mirroring along the LE from the center to the BL corner. There is some mirroring in the areas of maximum density, but much of it has been wiped away.

TREATMENT

1. The current housing tape was cut away and the cover glass was removed from the glass side of the negative. It was then discovered that the emulsion side of the plate has been affixed to the backing glass with double-stick tape. The plate and backing glass were submerged in a tray of acetone to break down the adhesive (Figure 45). After removing the shards from the backing glass, the plate was placed on an incline and rinsed with acetone to remove any residue (Figure 46). Upon removal of the shards from the cover glass, it was determined that the glass deterioration was limited to the cover glass and not the negative glass.

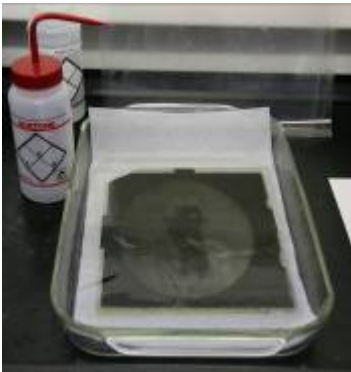


Figure 45

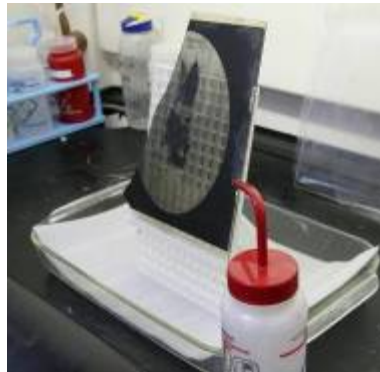


Figure 46



Figure 47

2. The remainder of the tape adhesive and carrier were removed with ethanol swabs (Figure 47).
3. The shard interfaces were cleaned with acetone swabs and the shards were assembled vertically with sticky wax and the aid of the light line (see case study 1). 25% B-72 in Toluene was then wicked into the shard interfaces and the plate was left in position overnight. The next day the plate was backed with a piece of mat board and the adhesive was left to cure for two weeks.
4. The wax was removed with a hot scalpel and Naphtha swabs. Excess adhesive on the glass side was removed with acetone swabs.

OBSERVATIONS

Notes on glass deterioration

The removal of deterioration from a cover glass is not acceptable because glass deteriorates from the outside inward; the removal of deterioration also removes what is left of the original surface and what remains will be glass whose integrity has been compromised. The glass beneath the deterioration is usually unevenly preserved and the surface may be pitted or appear etched^{vi}.

This object had a particularly poor stabilization housing prior to this treatment. The double stick tape used in the housing to attach the sandwich glass to the plate shards had cross-linked and attracted insect frass. The fact that the edges were only bound in four central areas (Figure 42), allowed the ingress of moisture, the environment's relative humidity fluctuated, and glass deterioration of the sandwich

glass was the result. The shards were also in contact with each other, causing grinding of the shards and damage to the emulsion (Figure 43).

New glass should and non-hygrosopic materials used when constructing a plate package. Spacers should be inserted so that the glass will not be in contact with the object.

Case study #9: Severely flaking gelatin Opaltype

Artist: Unknown
Title/subject: Portrait of Marin J. Shealy
Owner: Marin J. Shealy
Dimensions: (oval) 6.1 x 7.9 cm at widest points
Medium/Process: Opaltype: gelatine bromide DOP on milk glass with hand colouring
Object Date: 1925
Housing: A decorative copper alloy frame in a case constructed of leather, wood and red velvet.
CNS No.: 0311:54:1
Conservator: Jiu-an-Jiu-an Chen

TREATMENT SYNOPSIS

This photograph was surface cleaned, flaking emulsion was consolidated with B-72 in Toluene and Xylenes and the housing was repaired.

Before



After



DESCRIPTION

An oval, hand-colored Opaltype, circa 1925, with severely cracking gelatin binder and small losses.

CONDITION

Previous Treatment: No apparent treatment has been carried out.

Image Plate: The gelatin binder layer and pigment layer is severely embrittled and cracked with widespread flaking throughout the plate. The flaking is particularly severe in the lighter areas where there is less pigment such as the face, arms and dress

with numerous small areas of loss. There is a large area of loss of emulsion/pigment located in upper left of image near top of child's head. Fibres from the degraded velvet tray pad are present throughout emulsion/pigment layer.



Figure 48



Figure 49



Figure 50

TREATMENT

1. The surface dirt and loose velvet fibers were carefully picked away with a pair of small tweezers with a sticky tip under microscope.
2. The flaking emulsion was locally consolidated with 5% Paraloid B-72 in toluene and burnished slightly with a Teflon bone folder to encourage the lifted emulsion to glue down to the support. Again, this step was carried out under microscope with custom designed micro tool to deliver the consolidant precisely to the problematic emulsion. The consolidation was repeated again until all flaking emulsion stabilized.



Figure 51



Figure 52

3. The entire image was varnished with 10% Paraloid B-72 in xylenes, delivered with a fine air sprayer. This varnish was mixed with Polydispersion D for the image to retain matte surface.
4. Three small pieces of velvet strips of the similar color to the velvet backing on the back were attached to the inner wall of the brass ring to ensure that the image package and the velvet backing fit snugly into the ring.
5. The broken rail on the top of the case was adhered together with diluted hide glue and clamped for the adhesive to set for a day.

6. The image package was refitted back to the case.
7. A custom-made box was constructed to house the entire case.

OBSERVATIONS

The image is now stabilized and secured. The loss in the image was left untouched. It is recommended to have digital restored reproductions than to add modern materials to the original just for aesthetic reason.

The leather covering of the case is so thin and deteriorated. The attempt to remove the Scotch tapes will also remove the leather. It is decided to leave the tape, since it will not affect the image.

The case should be kept close as much as possible to prevent warping of the wood due to fluctuation in humidity and temperature in a domestic setting.

The image can be safely displayed inside the case as if needed. Caution should be taken seriously to prevent dropping of the image since it will be detrimental to the glass support.

The consolidant and the varnish secure the image well. However, extreme fluctuation of temperature and humidity could compromise the treatment and make the image layer unstable again. It is recommended to store the image in an environment that has temperature lower than 70 degree F and with the relative humidity between 40% to 50%. Fluctuation of temperature and humidity should be avoided as much as possible.

Case study #10: Broken stereo-transparency

Artist: Unknown
Title/subject: [Positive on glass of a full moon]
Owner: GEH archives
Dimensions: 3 ¼" x 6 11/16"
Medium/Process: Wet plate collodion or albumen positive
Object Date: Ca. 1890
Housing: Mylar sleeve
CNS No.: 0601:82:01
Conservator: Gawain Weaver

TREATMENT SYNOPSIS

The stereo-transparency was stabilized at the edges by applying dots of Epo-tek 301 epoxy. A custom cradle was made within the housing to support the curved glass.

Before



After



DESCRIPTION

A stereo-transparency on curved glass, that has broken into three pieces.

CONDITION

The plate is varnished and has the number "2415" written in white paint at the lower right margin. It has been bound together at the edges with a piece of frosted glass of the same size as the negative using an off-white tape. The emulsion side of the positive is facing out. While the existing tape was added at a later date, the frosted glass is likely part of the original construction, regardless of whether this particular piece of frosted glass is original or a later replacement.

The remnants of an earlier tape are visible in some places. The color of the negative indicates that it was bleached. See Figure 53 for a comparison with bleached collodion plates.

The glass support of the collodion image is curved, which would have greatly increased the risk



Figure 53

of breakage. There are two cracks on the right side of the positive running from the top to the bottom edge, resulting in a loose triangular piece of the positive, and two pieces still held in place by the binding tape. The loose triangular piece has a hairline crack bisecting the most acute angle. There is a brown discoloration at the top of the hairline crack and on either side of the crack that does not go through the image of the moon.

There are multiple fingerprints on the emulsion, many of which are black and seem to be the result of handling by fingers wet with silver nitrate. The binding tape is only partially intact and is holding the two outer pieces of the negative in an overlapped position.

TREATMENT

1. Removed the paper binding tape from the edges using a methyl cellulose poultice to soften the adhesive.
2. Cleaned the back sides of the positive and the diffusing glass with DI water and ethanol. The image side of the collodion plate was also lightly cleaned with a cotton swab dampened with distilled water.
3. The glass plate was repaired by tacking the broken edges at the margins using Epo-Tek 301. The crack on the left (nearest the center) re-separated during treatment, but it was decided that the support and binding tape was sufficient to hold it in place. The epoxy provides a slight cushion between the broken edges.
4. A curved support was made for the positive using strips of 4-ply mat board along the edges and tacked in place with Acryloid B-72.
5. The repaired collodion positive and its diffusing glass were bound with Filmoplast P-90 toned black with Sumi ink.
6. A U-shaped cradle made from 2 pieces of 8-ply mat board was cut to fit into the existing GEH archive sleeve and prevent the collodion positive from being compressed when stored in the drawer with other glass plates.



Figure 54



Figure 55



Figure 56

OBSERVATIONS

This treatment has a minimal impact on the plate with minimal introduction on new materials. The tacking of the edges of the breaks with Epo-tec 301 serves to stabilize the broken plate without introducing adhesive throughout the plate. This could have the advantage of being reversible in the future because of the small amount used. It would also avoid the possibility of yellowing that affects the aesthetics of the plate in the future: those areas where Epo-tec is present are covered with binding tape. B-72 in Toluene is a viable alternative. However, this method did not fill the shard interface with refractive index matching material and the break is still obvious.

The u-shaped cradle is an excellent housing. It protects the curved plate in the event that another object is placed on top of the plate. The plate should then be housed in a 4-flap enclosure and marked "FRAGILE! GLASS!"

Case study #11: Lantern slide with broken cover glass

Artist: Alfred Stieglitz
Title/subject: Maria Bellagio
Owner: GEH photograph archives
Dimensions: 8.5 x 10.3 cm
Medium/Process: Gelatin dry plate lantern slide
Object Date: Ca.1910
Housing: None
CNS No.: 0706:54:02
Conservator: Rosina Herrera

TREATMENT SYNOPSIS

Replacement of a broken cover glass and restoration of the original binding tapes with toned P-90.

Before



After

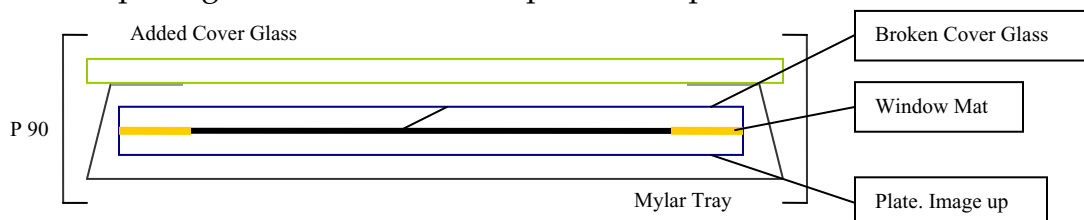


DESCRIPTION

A lantern slide by Alfred Stieglitz with broken cover glass and loss of the original binding tape.

CONDITION

Previous Treatment: The image package has been rebound to stabilize the broken cover glass. The image plate is inside a Mylar tray to protect the original binding tape from the P-90. A new cover glass has been added to stabilize the broken cover glass shards. The entire package is closed with Filmoplast P90 tape.



Glass Support: soiling, finger prints, accretions, glass deterioration

Final Image Material: silver mirroring

Original Binding Tape: broken, cover glass separated from plate, glass deteriorated

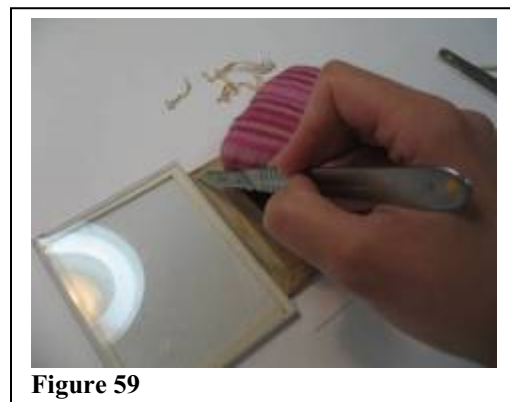
Cover Glass: broken in two pieces

TREATMENT

1. Recent rehousing was opened (Figure 58).



2. Labels with title and number and original binding tape were removed from the original cover glass (broken). The areas of paper with no inscriptions were locally wetted with water and removed. The binding tape had an inscription with the GEH number which was water soluble. This strip could be removed with dry methods (scalpel). Moisture application was needed in the label with the title, also water-soluble. These inscriptions were fixed temporarily with Paraloid B72 in acetone. The binding tape and labels were washed in water. During this process of removing the labels some paper tabs were found under the tape. It was recorded where they were to put them back later in the same place. Also under the label with the number "88" there was another label with the number "69"
3. The label with the title was broken along the fracture of the cover glass. It was laminated with Japanese paper and Methylcellulose
4. A strip of Filmoplast P90 was toned with Acrylic colors imitating the color of the original binding tape.



5. The package: new cover glass (same thickness as previous one), original paper spacer and plate were bound with one strip of toned P90 tape (Figure 60).
6. The original binding tape and labels were placed back on the same location on the P90 tape. The adhesives used were starch and Methylcellulose in the areas with no inscriptions and Aquazol and ethanol for the labels with inscriptions. Aquazol was not used for all the cases because it seems that it produced a color change in the paper.
7. The excess of P90 tape was cut and the fixer B72 was removed from the inks with Acetone (Figure 59).

OBSERVATIONS

This treatment was a removal of an unattractive new housing and the re-housing of the object with more aesthetically pleasing materials. Part of the conservator's duty is to treat the object so that is as close to the artist's original intent as possible. The first re-housing that this treatment replaced did not meet that requirement. The Mylar tray was a good innovation to protect the original paper tapes from the P-90 binding.

The replacement of the broken cover glass was an aesthetic decision. The shards were stabilized by the P-90 and the unbroken image glass. It may have been possible to repair the broken glass with an adhesive that matched the refractive index of the glass, such as Epotek 2-part epoxy. In the event that the cover glass is not repaired and is replaced, it should be retained and kept with the original object because it is a part of the object's history.

Preventive Measures

HANDLING

- The most common cause of breakage in the lab is the object slipping out of the conservator's hands when wearing cotton gloves. Neoprene or Latex gloves should be used instead to protect the emulsion from fingerprints that will cause deterioration over time.
- *Glass fragments should be handled as little as possible.* To that end, virtual assembly in PhotoShop may be necessary to determine the arrangement of the shards. See Appendix 3.
- A padded (foamed polyethylene) and tight weave tissue or Sintered Teflon lined box should be used for fragments. Do not let the fragments come into contact with the foam; any lifting binder will be very susceptible to snagging.
- Handle glass plates by two edges and carry flat. Do not handle by the corners.
- Work on a clean, dry, *padded* surface: such as a sheet of thin Ethafoam covered with blotter.
- Place glass plates on a flat surface binder side up.
- Never place any pressure on plate: label sleeves before placing the plates in them.
- Never stack bare plates.
- High use plates should be duplicated.
- Do force the hinges closed on cased images.
- Do not disassemble cased image without a photograph conservator.

HOUSING RECOMMENDATIONS

Intact bare plates with no flaking

House glass plates in four-flap enclosures and envelopes. All materials should pass the P.A.T. The four-flap enclosure will insure that any incipient flaking will not be exacerbated by inserting and removing the plate while sliding it out of the envelope. If four-flap enclosures are not feasible, the plates should be placed in the envelope binder side away from the seam to ensure there is no abrasion of the binder and that the adhesive cannot cause deterioration. This enables the object to be put into and removed from the enclosure without the risk of scratching that can result from sliding the object into and out of an envelope.

Plates should be stored vertically in document boxes, on the long edge. Interleave every inch with acid-free cardboard to support the plates^{vii}. The plates should be housed vertically, on their long edges, in a *partly filled* box with a spacer to minimize jostling during handling. For plates over 10 x 12", use over sized legal boxes. Only partially fill the box to prevent the box from becoming too heavy^{viii}. Acid-free corrugated board should be used to fill out the box to avoid shifting of the contents.

Boxes of glass plates should be stored on lower shelving and never above about four feet to prevent someone from having to lift the plate down from above their head. The boxes should further be labeled clearly: FRAGILE, HEAVY, and GLASS.

Intact bare plates with flaking binder

If the flaking is minor, *i.e.* a few small edge losses with no flaps or flaking towards the center of the plate, the plates should be housed in four-flap enclosures within their envelope. The envelope should be labeled: FLAKING EDGES, remove with care.

More severely flaking plates, *i.e.* plates with hanging flaps and/or cracking overall with incipient flaking in the center, should be duplicated and housed in four-flap enclosures within their envelope. Plates with more extensive flaking should be stored in sink-mats and stored horizontally. Housings should be labeled accordingly.

Broken plates

Broken plates deserve special attention. It is very important that broken shards do not come into contact with each other. This can cause damage to the binder and the glass edges such as chipping and additional breakage. Create a form-fit support by cutting 3 pieces of 4-ply mat board and place one on the shards on one of the pieces of mat board, emulsion side up, and trace the edges of the shard. Remove the shard and cut out the form, leaving two 2 pieces that will fit to the shards. Attach one of these pieces to a full size board and the second form to the second piece of board (Figure 61^{ix}) with wheat starch paste or 3M



Figure 61

#415 double-stick tape. The shards should sit level to below the top surface of the mat. The objective is to support each piece so that additional damage will not occur by placing the shards in contact. These are then placed in separate 4-flap enclosures and housed flat, and marked "broken plates / carry flat".

An alternative housing for plates that have been broken into many shards is suggested in a 1991 paper^x by Constance McCabe of the National Archives in Washington D.C.:

"Broken negatives are assembled in proper orientation for duplication but are housed in sink mats with the components separated with paperboard spacers attached with adhesives to avoid mechanical damage to the glass pieces... [Paper tabs are inserted] to assist in lifting out large pieces. These enclosures must be carried horizontally or the glass will slip away from its support... Negatives housed in sink mats are stored horizontally in stacks of three to six (depending on the size and weight) within storage boxes. Boxes are of the drop-front style with metal stays... Each box is marked with the cautionary label: "Caution: Broken glass. Carry Horizontally"."

It is extremely important that broken negatives housed in a sink-mat include pieces of paperboard to separate the shards. If this is not done, the shards will rub together, causing flaking of the binder and grinding of the glass. The sink mat should be constructed of mat-board and care should be taken that if there is any flaking binder that it is not exacerbated by rubbing on the edge of the sink-mat. A sintered Teflon lining will minimize this possibility.

Cased images should be housed in four-flap enclosures with a thumbnail photograph of the object on the outside of the box so that it can be determined what is in the box without opening the enclosure. Objects should be stored flat in larger boxes or padded drawers, or vertically in padded slots in boxes or drawers. Do not house glass plates in plastic sleeves.

ENVIRONMENTAL

Control of Relative humidity offers a significant improvement in the long-term preservation of photographic materials. A slight increase in RH will lead to the deterioration of the silver, binder, varnish and glass support, and a slight decrease on RH can lead to flaking of binder, and dehydration of the glass. Connie McCabe^{xi} recommends 30-40% RH. Below 30 and the binder will desiccate and above 40 the glass will start hydrating.

Stephen Koob of the Corning Museum of Glass recommends that the following guidelines be followed:

- No fluctuations in conditions
- Avoid temperature extremes
- Avoid spot-lighting (leads to uneven heating)
- Avoid cycling.

Cased images have their own requirements when it comes to their preservation. The base recommendations are 18 – 20°C and 40-50% RH. Do not store cased images <40% RH to prevent embrittlement of the case, and do not store them >50% RH to prevent brass mat and cover glass deterioration.

For all photographs on glass, the light levels should be kept below 50 lux (5 foot-candles) when they are on display.

ⁱ Bray 93.

ⁱⁱ Unpublished notes by Koob.

ⁱⁱⁱ Koob 2006, 73

^{iv} Clark 231

^v *Ibid* 235

^{vi} Koob 17.

^{vii} www.archives.gov/preservation/storage/glass-plate-negatives.html

^{viii} *ibid*

^{ix} Herskovitz 4.

^x *Preservation of 19th-Century Negatives in the National Archives* 1991, 68-69.

^{xi} McCabe, 1991; 40

CONCLUSION

Glass and photography go hand in hand. From cameras lenses, to glass plates, to enlargers and even frames, glass is has been integral to the art and science of photography since its inception. There are more than 20 photographic processes on glass, and when the permutations and variations of these are taken into consideration, the number increases to no fewer than 40 processes. In order to treat photographs properly, one must understand their history and production.

The treatment of the Abraham Lincoln interpositive presented the perfect opportunity to examine innovative treatment options for broken photographs on glass. As a result, many groundbreaking treatment options have been explored. Some other treatment options have been explored in the course of this research in the series of case studies.

This research has been an initiative to expand research into the history, care and treatment of this valuable part of the history of photography. This report has only touched how to fully understand the conservation of glass supported photographs. It is hoped that this report will encourage further research.

Appendix 1: A History of Glass as a Support for Photographs

Glass is an integral part of photography: One cannot separate glass from the photographic process without changing the meaning of the process. It is ubiquitous in the process: glass is used in cover glasses, lenses, as a support material, as studio glazing, for display purposes, in chemical bottles and processing trays and a myriad of other uses.

Glass has been used as a support in photography since before it was even called photography. Between 1816 and 1822, Joseph Nicéphore Niépce, coated a glass plate with bitumen in solution and exposed it, by contact, under an oiled paper engraving of Pope Pius VII. As sunlight passed through the engraving, the bitumen coating hardened to the glass in proportion to the density of the shading caused by the lines of the etching. The less the sunlight that permeated the etching, the more soluble the bitumen remained. When the glass plate was washed in oil of lavender, the unhardened portions dissolved away, leaving a clear, fine-lined image.

The importance of high quality glass as a photographic support was an issue revisited many times in the early years of photography. Observations of weeping and colour shifting in skylights and photographs lead photographers to seek out the best glass for their purposes. Even though glass was a very heavy and delicate burden...

“...glass is simply incomparable; its beautifully smooth surface, its rigidity, the ease with which it can be cut without interfering with the general flatness of the surface, and its unalterability [sic] when subjected to all ordinary chemical reagents, are qualities of so much value, that one can see no probability of its being usurped...” (from “Glass as a Burden to the Tourist” in The Photographic News August 1, 1884)

Only in the last 5 years has glass plate photography ceased production. Tmax on glass was produced for the Japanese traffic control division “Asahi” until 2001, and plates with special emulsions were produced for astronomical photography until a couple of years ago. Glass plate photography was utilized because the glass base would not distort like polyester bases might, and precise measurements could be extrapolated from the images. Both glass and polyester bases have been replaced with digital photography.

Glass composition

In its pure form, glass is a transparent, hard-wearing, essentially inert, strong but brittle, and biologically inactive material that can be formed to have very smooth and impervious surfaces. These properties can be modified by varying the heat treatment or by adding other components during the molten phase. The basic ingredients are: amorphous silicon dioxide (SiO₂), soda (sodium carbonate Na₂CO₃) or potash, (or an equivalent potassium compound to lower the melting point), and lime (calcium oxide, CaO, to restore insolubility). Glass produced with these ingredients contains about 70% silica and is called a soda-lime glass. Soda-lime glasses account for about 90% of manufactured glass.

Sand and alkali alone require a very high temperature to effect vitrification. The addition of chalk or limestone lowers the melting point. A certain level of purity is required for clear glass to be made. If substandard materials were used and there was iron in the sand, manganese would be added to counteract the resulting green tint. Although this produced a clear glass initially, upon exposure to sunlight the glass took on a violet hue. Many glassmakers opted to settle for the green or blue natural tinge that their materials produced. No two glass works used

the same mixture: products depended upon the sand and the alkali employed, and upon the degree of purity achieved. Some glassworks were so secretive about their mixtures that a professional mixer would be employed who would weigh up their ingredients behind locked doors.

Colored glass, also known as ruby glass (regardless of its actual colour), was produced in a number of ways. It might be “flashed” – a layer of coloured glass on a layer of clear glass – or “pot metal” – solid. Metals were added to the chemistry to produce vibrant colors. Getting the right mixture could be tricky and no two batches produced the exact same colour.

- Blue: oxide of cobalt, deutoxide of copper and perchloride of gold
- Green: deutoxides of copper and iron, oxide of uranium, and by mixing the colouring agents to make blue and yellow
- Violet: manganese and oxide of gold,
- Red: oxide of gold, manganese, oxide of silver, protoxide of copper, and peroxide of iron mixed
- white (opal): deutoxide of tin, phosphate of lime from mutton bones and arsenic
- Black oxide of iridium, manganese in excess, oxides of cobalt and copper and iron in excess.

CROWN GLASS

The pertinent methods of glass production relating to photography are crown, cylinder, (also known as broadsheet), and patent plate glass. French glassmakers produced Crown glass for the first time at Rouen in 1330, exporting it into the UK. It was first produced in London in 1678.

Crown glass is produced by blowing molten glass into a “crown” or hollow globe, using a blowpipe. When the globe has reached a sufficient size, a knob is made on the end opposite the blowpipe, and a solid “pontil” rod is attached. The globe is then cut off the blowpipe, leaving a hole at that end.

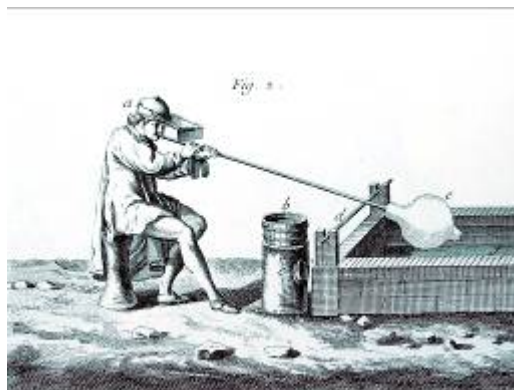


Figure 1¹

The globe is then rotated on the end of the pontil rod in the furnace mouth. A combination of the heat and centrifugal force causes the glass to spread outwards into a flat circle.

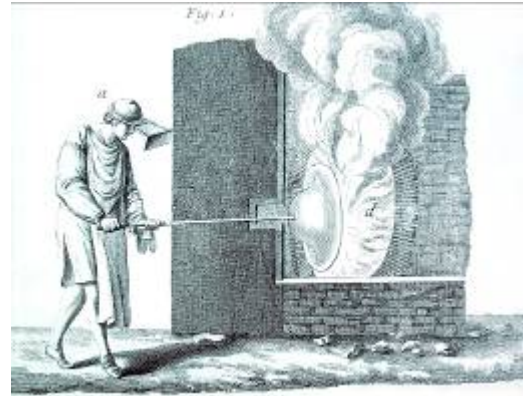


Figure 2

The glass disc is then removed from the furnace and rotated until the glass spreads out into a disc up to five or six feet in diameter. The pontil is then removed and the disc is transferred to an annealing oven to cool slowly and harden.

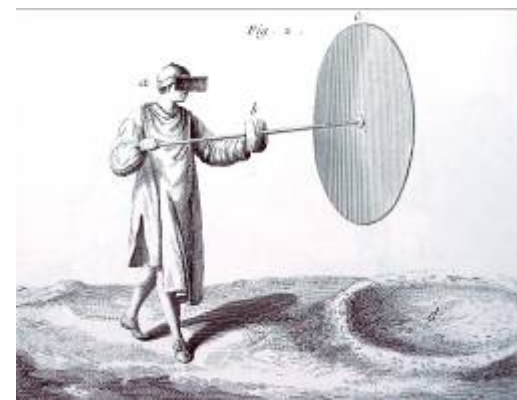


Figure 3

Once set, the glass is cut into the required sizes. The thicker section in the center, the “boss”, left in the center where the pontil rod had been attached is the origin of the bulls eyes or bullions sometimes seen in old windows: they were the cheapest glass available.

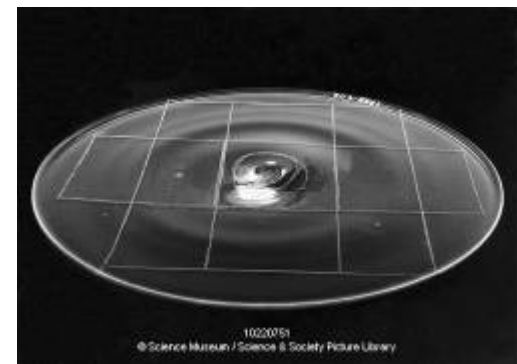


Figure 4ⁱⁱ

By the 18th Century quality was often very good with an almost unmarked fire-finished surface of pure silica. Because of its finer quality, when compared to cylinder or cast glass, this process predominated until the mid 19th century. Flattened crown glass was used as cover glasses in ambrotype cases because it was thinner and had greater clarity than the other glasses available.

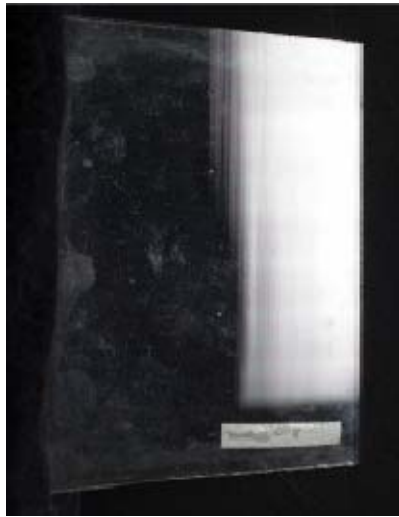


Figure 5



Figure 6

Many cover glasses exhibit the markings of crown glass production. Figure 5 is an example of a cover glass from the GEH archives that has vertical streaks in the surface. These are artifacts of the crown glass process. The centrifugal force involved in the flattening process produces waves in the molten glass; therefore, cylinder glass is not truly flat: it has subtle ripples in its surface. Figure 6 is another example of a glass manufacturing process: a bubble, or “bleeb” in the structure of the glass, caused by an air pocket formed in the molten glass that became stretched during the blowing process.

CYLINDER GLASS: THE ROOT OF PATENT PLATE GLASS

Broad Sheet was first made in Sussex in 1226, but of poor quality, and fairly opaque. Manufacture slowly declined and ceased by the early 16th Century. This method left many defects when compared to crown glass: cockles, waves, strings, knots, dust, scratches and burnt surfaces, but was cheap.

Cylinder glass, also known as broad sheet glass, production begins in the same way as crown glass: molten glass is gathered on a blowpipe and blown into a bubble (Figure 7).

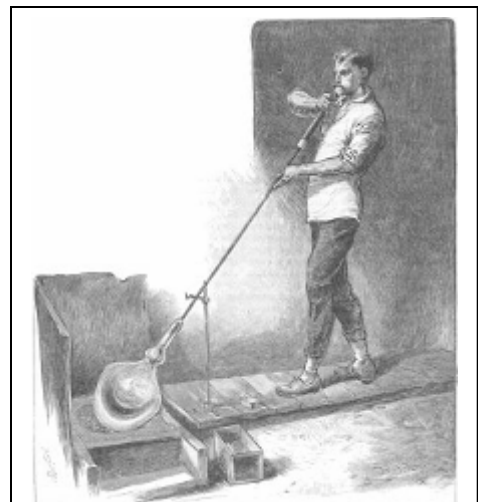


Figure 7

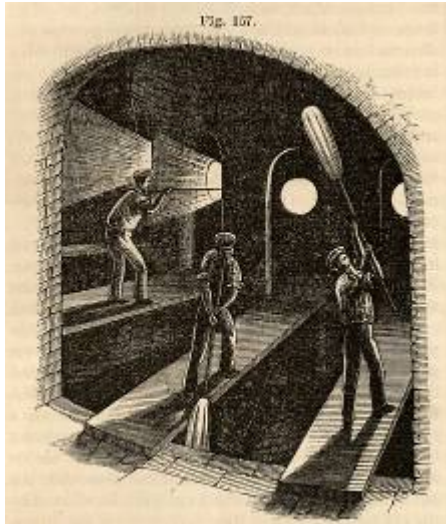


Figure 8

Once the bubble is of sufficient size, the entire blowpipe is swung in trenches, with occasional reheating and blowing, to elongate the bubble (Figure 8).

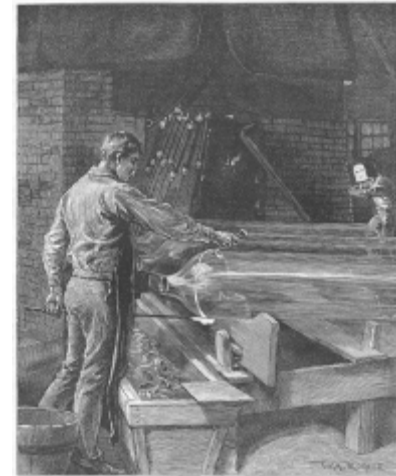


Figure 9

When the bubble reaches the appropriate length and diameter, the ends are cut off and the resulting “cannon” is inscribed along its length while still hot (Figure 9).

It is then taken to the flattening kilns. The cylinder is cleaned and placed on a stone near the furnace. When it is ready, the flattener introduces a long iron rod into the cylinder and lifts it into the furnace, placing it upon a large slab of stone covered with glass. As the cylinder heats up, the line inscribed with the diamond cutter starts to separate and the flattener teases the sides of the glass flat (Figure 10). The flattener then takes an iron rod with a block of wood on the end called a “polissoir” and rubs down all the cockles and waves (Figure 11). The stone is removed from the furnace, the sheet of glass slid off and placed in the annealing kiln.

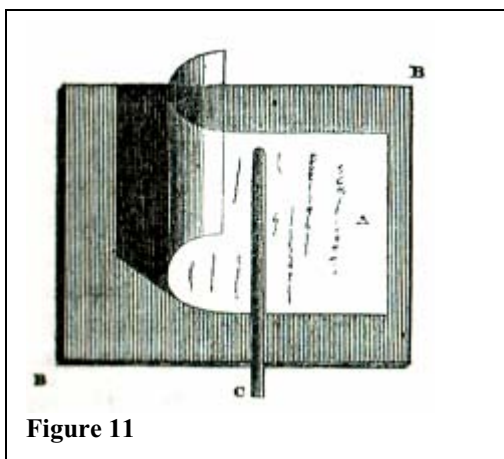


Figure 11

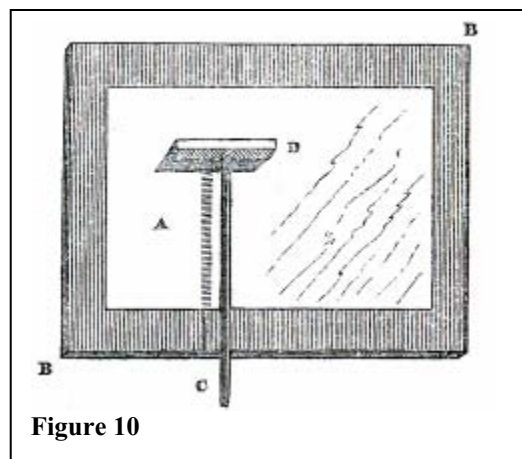


Figure 10

Plate glass developed out of the manufacture of cylinder glass and the need for higher quality glass. The ingredients varied with manufacturer, with necessary care taken concerning purity. Early plate glass was made from cylinder glass by laboriously hand grinding and polishing both surfaces.

PATENT PLATE GLASS

Patent plate glass evolved from cylinder sheet glass, whose surface has been rendered plane and brilliant by a process of grinding and polishing with machinery. Originally, an English invention, it was soon made throughout Europe and the US. Most of the defects in glass came from the laying down of the hot glass upon an uneven surface. To remedy these defects the glass was ground down to a level surface and polished. The first method, patented by a Mr. Chance, involved placing two sheets of rough glass in a machine that rubbed the two pieces together with sand and water until smooth. Both sheets were then removed and then treated with emery powder, and then rouge for the final polish. This made the firm's glass exceed all others in brilliance and transparency. The hand polishing of the past could not accomplish this level of polish. By May of 1841, with the aid of the new machines, the company was turning out more than 4,000 feet of glass per week to meet the enormous demand for the patent plate glass.

Patent plate glass could be made 1/16 of an inch in thinness. A disadvantage of the patent plate was that the surface was softer, having lost its hard-fired outer layer. It is more easily scratched and stained. Due to the slowness of the process and the amount of materials used and lost in its creation, Patent plate glass was among the most expensive glass for photographic purposes.

MACHINE-DRAWN CYLINDER - 1903

This method was invented in the United States and applied in the UK by Pilkingtons from 1910 to 1933. It essentially, ended the manufacture of hand-blown cylinder glass.

A circular disc, or *bait*, was dipped into a pot of molten glass. 40 ft high cylinders of glass were drawn vertically from a circular tank while compressed air was simultaneously blown in. The glass was annealed and then cut into 7 - 10ft cylinders, which were then cut lengthways, reheated and flattened. This process was used in the UK into the late 1920's.

FLAT-DRAWN SHEET - 1913

The glass was drawn vertically in a flat sheet until it cooled sufficiently to allow the glass to be cut. The Belgians invented the original process in 1913, but it did not reach the UK until 1919. In 1901 *Emile Gobbe* and *Emile Fourcault* started work on a **pulled glass** method of production. The patent was granted in 1905, and in 1914 the first industrial plant was built. This method produced a thinner, very fine, and more uniform sheet of glass with few variations in the surface. The first patent for the totally mechanical drawing of glass was awarded in 1901 to the engineers Gobbe and Fourcault. Created in the glassworks of this firm in Dampremy, it was to be used internationally after the First World War. The glass is drawn upwards from a tank furnace and cooled gradually on its way to a drawing pit. All that is required in the process are a worker to hold the sheet that comes out and another to cut it with a diamond. The patent was to be improved in the United States under the name "The Pittsburg Process". A variant on the Fourcault model, the Libbey-Owens process appeared in 1915 in the USA. All these processes were later replaced by 'float-glass'ⁱⁱⁱ.

The Pittsburg process, is now extensively used in the United States. Although it is exceedingly difficult to carry out, the results are most satisfactory. The process avoids the inherent defects of the Fourcault and the Libbey-Owen processes. The sheet is drawn vertically from an open bath of glass in which a bar of submerged fireclay defines the position of generation of the sheet, and the width is maintained by a peculiar device known as the "Edge Bowl."

BELGIAN GLASS



Figure 12^{iv}

The primary producers of glass until the beginning of the 20th century were France, Great Britain, North America and Belgium, with Belgium being known for the finest quality glass. Belgian glassworks were very economical in their outlay of capital: they employed cheap labor and used less expensive construction methods than other countries. They also had the advantage of very pure raw materials. Belgian sand is like no other. The sand that lies under the surface soil is very clean, white and fine; it allowed Belgium glassworks to avoid the cost of washing and drying. Other countries used sea-sand, which had to be washed and dried before use. Another drawback to this sea-sand is that it contained iron, resulting in a green tint in the final product. Figure 1 illustrates the area of fine, river washed sand - designated by the lighter area of the map (centers of glass production and shipping are designated with white text). Though the Black Forest and Strasbourg, in Germany, produced glass as well, Southwest Belgium and Northern France were the most important centers of glass production - partly because Germany used a closed market system so it was not in direct competition.

Even before it became known for its glass, Belgium was already a very industrialized region with was easy access to coal, wood, and metal works. Before glass, these areas were the center for the textile industry and the factory owners were the first amateur photographers. Van Monhoven and Blanquart-Evrard were both from this area. Their families were leaders in the textile industry – and therefore among the privileged class. They had the time, money and the education to expand the field of photography. The exchange of photographic chemistry and ideas was common in the region.

In the 1830's glass production was still small scale in Holland (Netherlands) and France. The experience and knowledge was hired in by France (the first industrial center in France was in Saint-Gobain) from Belgium. After a time though, many of the people who had emigrated from the area to work in France, came back to develop the industry in Charleroi, Belgium. It was a good time for private enterprise in Belgium and people had the initiative to begin private companies. Some companies have survived to the present day and have turned into a big industry.^v

Walloon, in central southern Belgium, developed into an important European production center for glass in the second half of the 19th century. It became a serious competitor of the then-exclusive French glass industry in Saint-Gobain. Besides the presence of raw materials (sand) and energy (coal), Walloon benefited from the growth and specialization of the glass industry. That formed the special economic trump-card of the Walloon glass industry.

One supplier named Beernaert, established a factory in 1880 that produced dry plates for photography, using a formula developed by Von Monhoven. By 1886, they were employing 69 workers and staff^{vi} and were among the most respected producers of glass for photography, known for their high quality. The factory produced 400 m²/day. The Belgians constructed highly economical furnaces that reached much higher and even temperatures than comparable English furnaces. This resulted in a reduced need for added alkalis (to reduce the melting point), and therefore produced glass of much higher quality and purity. Because of this, Belgian cylinder glass was prized as the best for cover glasses in daguerreotype and ambrotype cases, so much so that companies were established that provided glass exclusively for photographic purposes.

Charleroi, which became the center of flat glass production, is the cradle of the industrial revolution in Belgium. The scale of production was on a much bigger scale in Belgium than France or Germany – it was localized in Charleroi in the Walloon region. The Walloon economy experienced a strong development in the 19th century, essentially in the regions of Liège and Charleroi. Belgium was then the first country in continental Europe to undergo an industrial revolution in the early 1800s, mainly based on iron and coal industries. Charleroi is geographically located at the center of an enormous coal basin, called Pays Noir (black country). One can still find slag heaps surrounding the city. Most iron comes from the Lorraine basin in France, while nonferrous metal products made from imported raw materials include zinc, copper, lead, and tin.^{vii}

PRODUCTION

There were three large product groups; each arose with their own factories: window glass, glass bottles, and crystal. The Belgian glass industry was very specialized and the division

of labor was critical to its success. As an example of this specialization in the production of cylinder blown glass, what had previously been the job of one person was divided among a number of people. One person created the cannon, which was then passed onto someone who would scribe the glass along the length, which was again warmed and opened to make the sheet. This glass was specifically used in industrial architecture and luxury home construction.

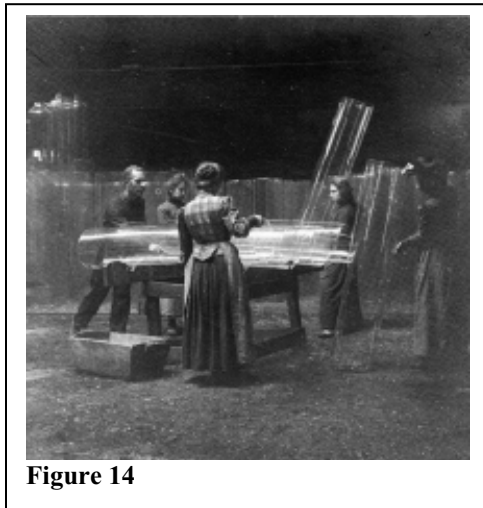


Figure 14

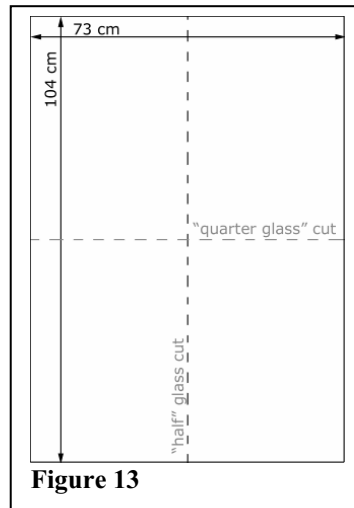


Figure 13

The glasscutters in the plants were women (Figure 13). They were well paid and were expected to have a high standard in the precision of the cuts. The high degree of quality control resulted in the reputation of Belgian glass having no deviations or sharp edges. The standard sheet size was 104 x 73 cm - a standard that remained until very recently. All cuts were made in relation to this size (Figure 14). Cuts would first be made along the length (36.5 x 104), making “two-glass” size, then the short way (36.5 x 102), making “four-glass” size. Even to this day windows are described by one-glass and two-glass sizes.

ⁱ Diderot’s Encyclopedia

ⁱⁱ National Media Museum, Bradford

ⁱⁱⁱ http://www.charleroi-museum.org/mdv/code/en/tech_fourc.htm

^{iv} The base of this map was made using Microsoft MapPoint online.

^v Personal communication with Pool Andres of the Belgian Museum of Photography in Antwerp, Belgium

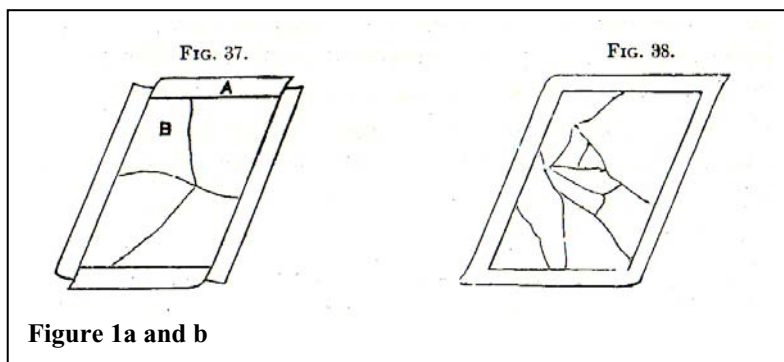
^{vi} *Directory of Photography in Belgium: 1839-1905*

^{vii} <http://www.crwflags.com/fotw/flags/be-whtcr.html>

APPENDIX 2: HISTORIC TREATMENTS

Historically, broken negatives were often considered irreparable and discarded. There were some cases where the negative was considered particularly valuable and warranted an effort to be put forth to save the image. One of these methods, described in *The Photo-miniature*, 1913, is to strip the film (if the film is unbroken) and transfer it to a new support: “Probably nine out of every ten attempts would prove failures”ⁱ. If the film was broken there was commonly thought to be no remedy. The article goes on to describe a method for making an interpositive of the broken plate that is touched up to negate the break marks (which would turn out white or black on the interpositive. From this, copy negatives can be made to replace the original.

The second edition of *Hearn’s Practical Printer*ⁱⁱ, published in 1878, offers a method of repairing a broken collodion glass plate negative. According to Hearn, the primary purpose of repairing a broken negative is to make it strong enough to resist the pressures from the backboard of a printing frame while printing. He offers two methods. The first involves assembling negatives that have been broken into two to four pieces, with no breaks in the center of the plate (ie. All of the breaks have at least one side meeting the perimeter of the plate). The plate shards are assembled, emulsion side down, on flannel and one-inch wide strips of glued paper are applied to the perimeter of the plate on the glass side, permitting about half an inch of the width to project out beyond the glass (Figure 1a and b). Then wrap the extra paper around tightly onto the varnish side of the negative. This method held the pieces together tightly and allowed for use in a printing frame.

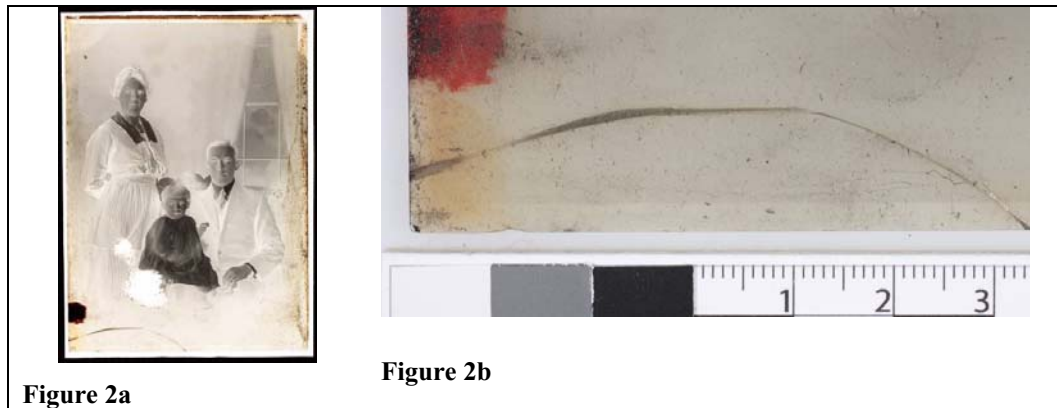


The second method described was for negatives that have breaks in the center of the plate (Figure 1a and b). This method called for the application of a secondary support of glued paper on the glass side, slightly larger than the negative. When the negative is in place, the extra paper is pulled up around the perimeter of the plate and affixed to the varnish side of the negative, outside of the printing area. The mounted negative is then turned over and burnished from the center out to remove any air bubbles. The contraction of the drying paper will pull the pieces of the negative together tightly. The negative can now be used in a printing frame.

Adhesives

There were also cases where repair of the glass was deemed acceptable: usually if the break was in an inconspicuous place such as a corner or edge (Figure 2a). The two most popular adhesives used to mend glass were **dichromated gelatine** and **Canada balsam**. Dichromated gelatine is made by soaking gelatin in water until swelled, then heating over a burner until it is melted and adding acetic acid as a hardenerⁱⁱⁱ. The resulting glue is transparent and is useful in

cementing glass sheets together. It would also have been used for face-mounting photographs to glass as in the Crystoleum and Ivorytype processes. Figure 2a is an example of a gelatin glass plate negative that has been broken in the lower left corner. Figure 2b is a close up of that area, most likely repaired with dichromated gelatin. The repair is not ideal: dichromated gelatin does not match the refractive index of glass and therefore, is not a transparent repair.



Canada balsam is a turpentine made from the resin of the Balsam fir (*Abies Balsamea*). Due to its high optical quality, its refractive index ($n = 1.55$, very close to that of glass), and its purity, it is mainly used in optics as an invisible-when-dry glue for glass^{iv}. It is soluble in xylene, amorphous when dried, and it does not crystallize with age, so its optical properties do not deteriorate. It was commonly used for affixing lenses and Cutting Ambrotypes together (see p.20 in *Process History*), the varnishing of lanternslides, and the protection of any transparent surface from the environment^v.

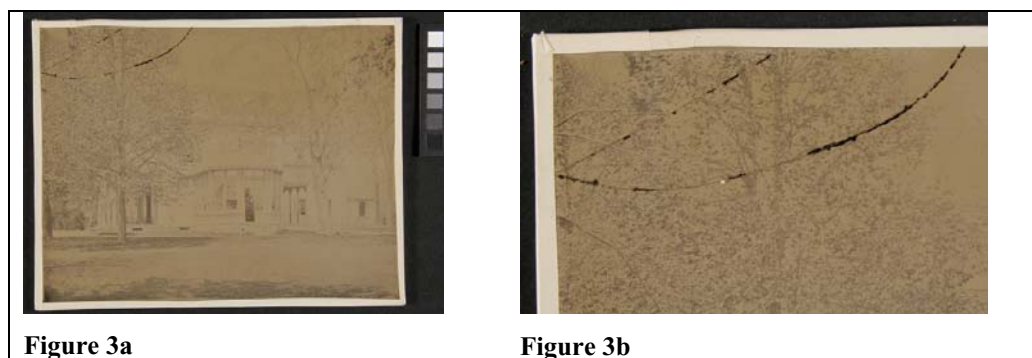


Figure 3a and b is an example of a more complex historic repair. The negative is broken in the top left corner. Shards are masked with a dark material along the fracture interfaces and the pieces are fitted together, sandwiched between two pieces of glass, and bound completely around the perimeter. It is uncertain if the pieces have been glued together, an unnecessary step because the glass sandwich and tape are sufficient to keep the pieces from grinding together. The fact that this is a collodion negative, and therefore milky and not clear (like a gelatin negative, see Figure 2a, above), is further reason why it is not necessary to use an adhesive on the cracks. The blacking material will make a white line in the final print, which can then be retouched.

ⁱ Bergmann 315.

ⁱⁱ Hearn 93-94.

ⁱⁱⁱ *Book of formulas* 6.

^{iv} http://en.wikipedia.org/wiki/Canada_balsam

^v Dick 215.

Appendix 3: PhotoShop Assembly

In the case of an object that has been broken into many shards, initial assembly should be performed by scanning the shards into files that can be manipulated in PhotoShop to determine their positions. This minimizes handling, protects the binder and any mirroring and reduces the chance of further damage to the glass. Blind cracks are very susceptible to separation.

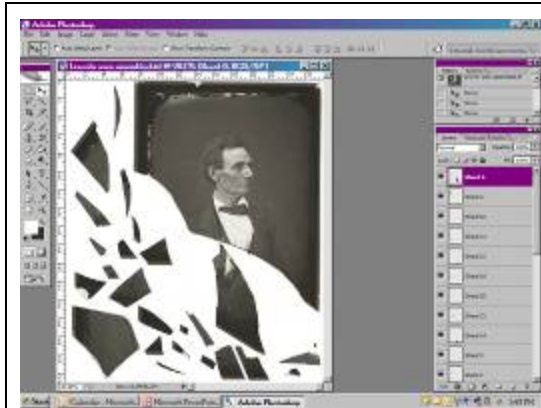


Figure 1

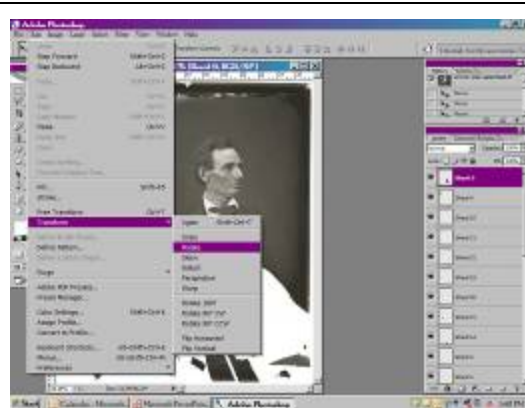


Figure 2

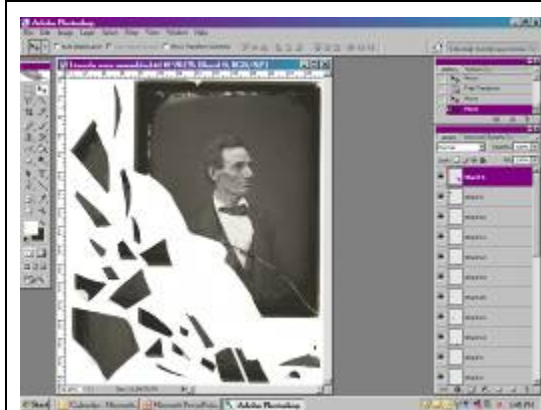


Figure 3



Figure 4

To assemble the shards in PhotoShop, the pieces must first be photographed or scanned on a transmissive illumination flatbed scanner. It may be more convenient to photograph or scan the shards all at once so that they will have a precise size relationship to each other. Each shard should then be selected and made a separate layer. In the case of Figure 1, 26 layers were created. Select the first layer to be manipulated, and select the rotate function under edit > transform > rotate (Figure 2). Rotate the piece until it reaches an approximation of the area in which to be moved and drag it into place (Figure 3). Select and manipulate the rest of the layers until the object is assembled (Figure 4).

This method of assembly will not only protect the delicate emulsion and glass from the further damage that can occur by physically manipulating the shards, but will give the conservator an idea of any other problems with the piece. In the case demonstrated above it was learned that five shards were missing. This is essential information for the conservator wishing to reassemble the pieces.

APPENDIX 4: AMBROTYPE DOUBLE-VIEW HOUSING: a modification of a design by Ryerson student Dawn Vernon

1. Create a guide for building the frame:
Measure the outer dimensions of the ambrotype to be housed. On a sheet of paper, draw a square of the same dimensions, a second square approximately 2cm larger (to compensate for the pinchpad)..
2. Make a frame for the ambrotype: Measure the thickness of the ambrotype. Using the template as a guide, build up pieces of Davy board in a pinwheel fashion around the outer line until the height matches that of the ambrotype. 3M double stick tape works well. Stagger the pieces with each layer to add strength to the structure (Figure 2).
3. Cut a piece of glass to the same size as the frame and affix it to one side of the frame with double stick tape. Paint the inside edges of the frame with black watercolour. Cover the top and side edges with one piece of black paper. Black paper is preferable because it will not show wear as much as a lighter colour (Figure 3a and b).
4. Create frame overlay: using a piece of 2-ply mat board, cut a window of the same dimensions as the frame. Cover this with black paper (Figure 4a and b).
5. Create the pinch pad: Cut a 1" strip of acrylic velvet a little longer than the inside circumference of the frame. Lay a line of 1/4" double stick tape just off center along the length of the velvet strip and fold over (Figure 5a and b). Glue this double strip of velvet, fold side up, along the inside of the frame to create the pinch pad. The ambrotype should fit snugly into this frame.
6. Create the outer spine and covers: cut two pieces of Davy board to the same dimensions as the frame and a spine piece to the same dimensions as the thickness of the frame. Align the cover spine pieces,

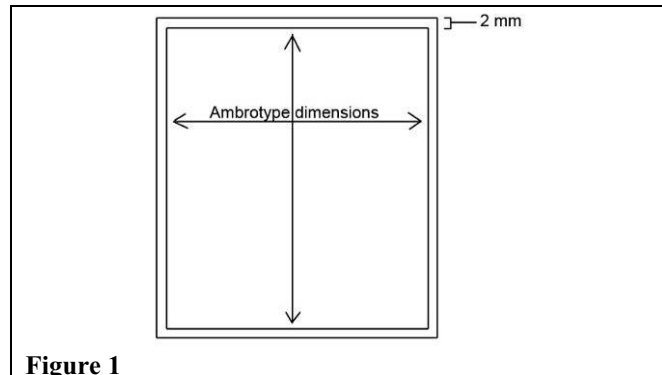


Figure 1

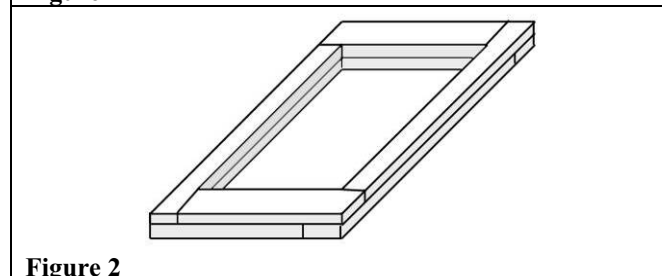


Figure 2

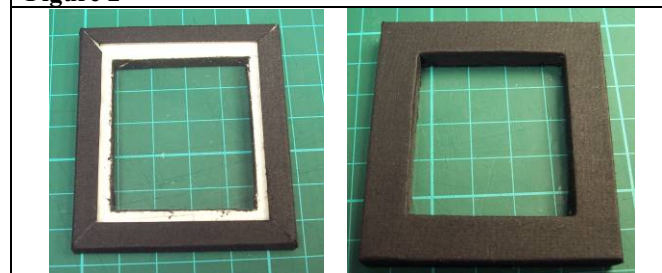


Figure 3a and b

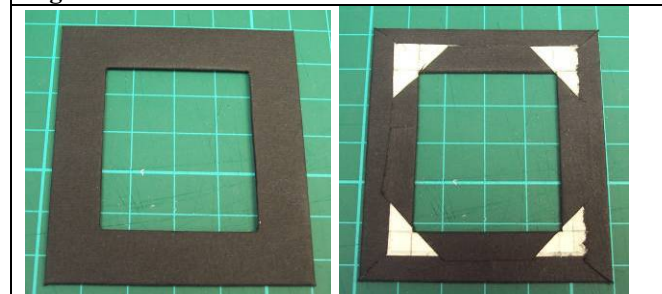


Figure 4a and b



leaving a slightly larger than board width gap between the spine and the cover boards. Cover this on the outside with book cloth, wrapping the edges over to the inside of the covers (Figure 6).

7. Cover the inside of the cover with two pieces of book cloth: Cover one side of the cover and spine with a piece of book cloth slightly wider than the distance, leaving a tab just past the far edge of the spine (Figure 7). In the second piece of cloth, cut a window the same size as the ambrotype and inlay a piece of velvet as a pad. Glue this to the other side of the cover, leaving a tab next to the near edge of the spine (Figure 8).
8. Complete the housing: Apply glue to the inner edge of the window and insert the frame and window on either side of the tabs, taking care that the top and bottom edges align with the cover (Figure 9 and 10). Close the housing and dry under weight.

Figure 5a and b

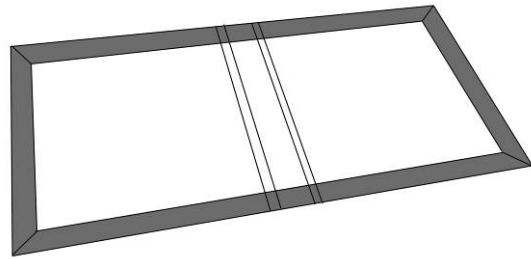


Figure 6

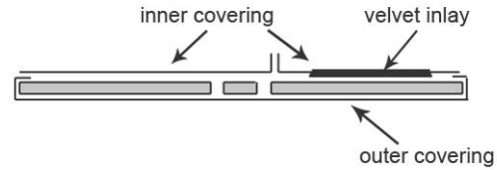


Figure 7



Figure 8

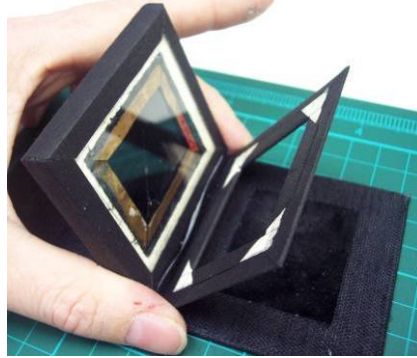


Figure 9

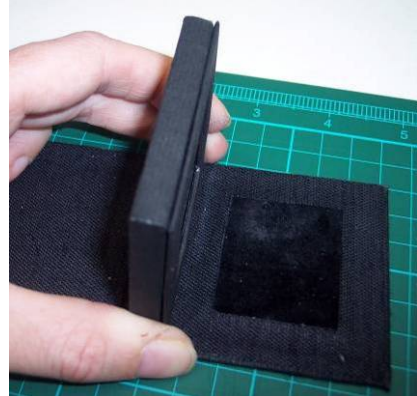


Figure 10